MOTOR REPAIR
AND
OVERHAULING

VOLUME IV

ELECTRICAL AND ACCESSORY EQUIPMENT

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CONTENTS OF VOLUME IV

METHODS OF DYNAMO CONTROL

THERE are many methods of regulating the dynamo voltage. A mechanical governor was used on some of the early types of dynamos, but is now obsolete.

The third-brush method of operation is now very largely used and serves to regulate the output at high speed. The theory and principle of the third-brush method of operation is explained later.

Electromagnetic regulation has also been used to provide constant current or constant voltage, and combined voltage and current regulation has also been adopted.

Compensated voltage control is the latest development of all where a plain shunt-wound dynamo is used with an electromagnetic regulator. The foregoing covers the main principles of dynamo regulation.

Modifications of the Third-brush Machine

There are further modifications, particularly on the third-brush type of machine, where we have third-brush regulation associated with :

(*a*) Thermostat control.

(*b*) Manually controlled field resistance.

(*c*) Lamp-load control.

(*d*) External voltage regulation.

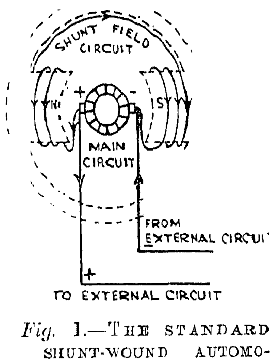


Fig. 1.—THE STANDARD SHUNT-WOUND AUTOMOBILE DYNAMO

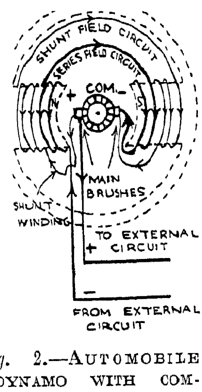


Fig. 2.—AUTOMOBILE DYNAMO WITH COMPOUND WINDINGS

Dynamo Regulation

The standard automobile dynamo is shunt-wound, as illustrated in Fig. 1.

In certain cases compound windings are used, as illustrated in Fig. 2. If the shunt and series windings of the compound machine are wound in the same direction, they have the usual cumulative effect, and if wound in

opposite directions they oppose each other, producing the well-known "differential" effect.

Dynamotors or motor generators incorporate a compound winding which consists of a series field winding and a shunt field winding, which are wound in opposite directions on the field poles.

When used as a motor the two windings have the cumulative effect of magnetising the field poles, and when used as a dynamo they have the differential effect.

Why the Dynamo Output must be Regulated

The dynamo most used in practice is the shunt-wound machine where, as is known, the e.m.f. is dependent upon the number of lines of force cut by the armature conductors, the number of conductors and the speed at which the armature revolves, or the rate of speed at which the conductors cut the lines of force. An increase of dynamo speed will, therefore, produce an increase of voltage and for this reason the plain shunt-wound machine used for car lighting would, at high engine speeds, develop such a voltage as would cause the lamps to burn out and too high a charging rate to be passed to the battery.

Methods of Limiting Dynamo Output

It is, therefore, essential to provide some means of preventing the dynamo increasing its output above a normal limit. To achieve this object various methods are available which can briefly be summarised as follows :

(1) Regulation of the voltage by maintaining a *constant voltage* from the dynamo with a variable current.

(2) Regulation of the current by maintaining a *constant current* with a variable voltage.

(3) Regulation of both voltage and current.

In considering the various methods it is as well to have these fundamental issues well in mind.

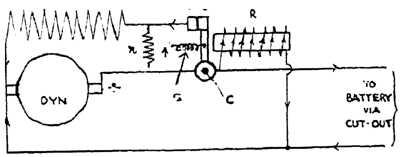
It will be appreciated that the number of magnetic lines of force and the speed at which they are cut by a given number of armature conductors governs both the voltage and the current, and conditions which affect one equally affect the other. In practice, however, certain types of machines are designed with means which decrease the lines of force in proportion to the voltage produced by the dynamo, and in other cases a decrease is obtained through the current produced by the dynamo, and in the third case both by current and voltage.

DYNAMO REGULATION METHODS

To maintain either a constant voltage or a constant current, or both, several methods are available, comprising :

1. Mechanical Hand Control

In this case the operation is similar to that used with an industrial shunt-wound dynamo, a shunt field resistance being manually operated in order to obtain constant voltage output. This method is obviously not practicable for use on the motor-car.



3.—SHOWING THE ELECTROMAGNETIC METHOD OF DYNAMO REGULATION

2. Mechanical Automatic Control

Several forms of automatic control have been devised, operating upon the principle of a centrifugal governor clutch. Such methods are, however, now obsolete and need not, therefore, be described.

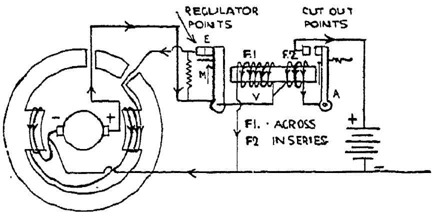
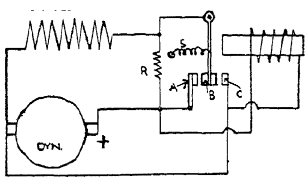


Fig. 4.—SHOWING COMBINED VOLTAGE CURRENT REGULATION IN A SINGLE ELECTRO-MAGNETIC

3. Electromagnetic Method

In this case a resistance is inserted in the shunt field circuit automatically by means of an electromagnetic device used exterior to the dynamo. A very considerable number of different designs of electro-magnetic controls have been developed. The basic principle of the method is illustrated in Fig. 3. This shows the dynamo with its shunt field (*F*), a resistance unit (*r*), and two contact points (A and B) securely held together by a spring (*S*) and electromagnet (*R*). The field circuit is from the dynamo positive terminal through the hinge (*C*), the contact-breaker points, the field coil to the dynamo negative terminal.



'ig. 5.—SHOWING ELECTROMAGNET WITH A SHUNT WINDING AND DUAL CONTACTS

When the Dynamo Speed Increases

As the dynamo speed increases the voltage will tend to rise. Since the electromagnet (*R*) is connected across the dynamo terminals, this rise of voltage will be sufficient to energise the core and cause the points (A and B) to separate. This automatically inserts in the field circuit the resistance unit (*r*). The resistance immediately causes the field to weaken and will reduce the voltage.

This reduction of voltage will be applied to the electromagnet (*R*),

which will be weakened sufficiently to allow the spring to draw the points (A and B) together again. The resistance unit (*r*), now cut out of the circuit, permits the dynamo voltage again to increase, thus energising the resistance unit (*r*), opening the contact points (A and B), again inserting the resistance unit (*r*), which will once more reduce the voltage output.

A Similarity to the Tirrill Regulator Principle

This rapid sequence of operations causes the controller contact breaker points to vibrate; in short, the principle is generally similar to the Tirrill regulating principle, which is considerably used in service on large industrial applications.

Voltage-regulation Control—

The factor which determines the opening of the points (A and B) is the dynamo voltage. The regulator is usually set to operate at 15–16 volts in the case of a 12-volt system and 7½–8 volts with a 6-volt system. Adjustments can be obtained by altering the tension of the spring (*S*). When the tension of this spring is increased, the dynamo voltage is raised, and vice versa.

When the car speed is less than the cutting-in speed, say 8–10 miles per hour, the voltage of the dynamo will be less than the battery voltage and the electromagnet will be insufficiently strong to hold the points (A and B) apart. At this point the cut-out will have opened, the dynamo will have been disconnected from the battery, and the ignition and any lighting load will have been supplied by the battery direct.

Since the operating conditions in the foregoing example are governed entirely by the dynamo voltage, this method of control is voltage regulation.

—and Current-regulation Control

It will obviously be possible to use the same basic principle to cover current regulation. In this case the shunt winding on the electromagnet is replaced by a series winding, so that all the charging current to the battery will flow through the electromagnet.

The operation will be similar to the voltage regulator previously described, the characteristic of the system, however, being to keep the charging current constant independent of the state of the battery, the regulator being designed to operate on a given load. With such a system the removal of the battery would immediately put the regulator out of action, and if the dynamo were driven at a high speed with the battery removed from the car its voltage would increase to an extent sufficient to burn out the field coil unless a field fuse is fitted.

Combination of Current- and Voltage-regulation Control

It is possible to combine voltage and current regulation in a single electromagnetic unit, as illustrated in Fig. 4. In this case the core of the

electromagnet has two windings, one shunted across the dynamo terminals and the other in series with the battery, both windings being in the same direction on the core.

In the case of a 6-volt system, when the voltage of the dynamo reaches about $6\frac{1}{2}$ volts the current passing through the shunt winding magnetises the core sufficiently to draw the blade of the cut-out against the spring tension, thus closing the cut-out points. The charging current then passes through the series winding and the cut-out points to the battery. If the voltage *or* the current increases above normal, the regulator contacts (on the left of the core) are opened, inserting the resistance in the field circuit, reducing the dynamo voltage in the same way as previously described.

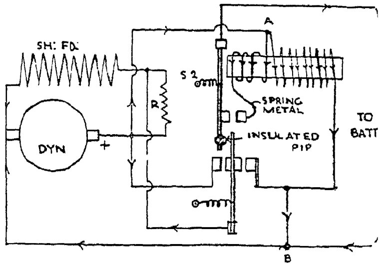


Fig. 6.—ELECTROMAGNET AS SHOWN IN FIG. 5, BUT WITH A COMBINED VOLTAGE REGULATOR

It will be observed that in this case the regulator and automatic cut-out are incorporated in one unit.

Since with this system the coil in series with the battery takes a part in the regulation, removal of the battery from the car may damage the dynamo unless the battery cables are joined together when the battery is removed.

COMPENSATED VOLTAGE-CONTROL SYSTEM

A reference to Fig. 5 will show an electromagnet with a shunt winding and dual contacts. The operation will normally be as previously described, but an additional contact (C) is fitted which short-circuits the field entirely in the event of very fast speed which causes an exceptionally high voltage.

Preventing Exceptionally High Voltages

Whenever there is a tendency for an exceptionally high voltage to be developed the strength of the magnetic core will be sufficient

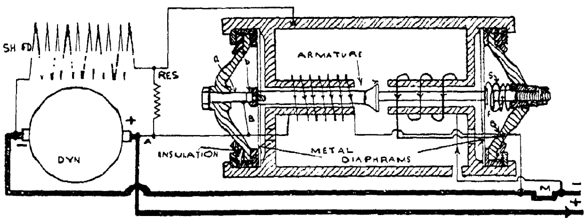


Fig. 7.—SHOWING SPECIALLY DESIGNED REGULATOR

This regulator does not incorporate an automatic cut-out and acts as an output regulator only.

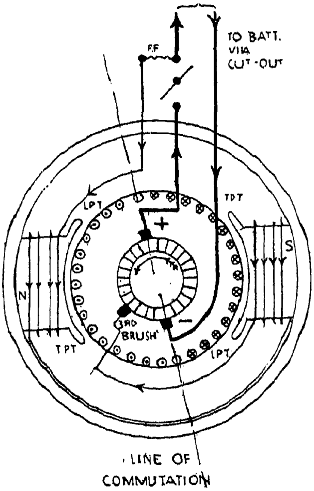


Fig. 8.—DIAGRAM OF A TYPICAL THIRD-BRUSH DYNAMO

to pull the contact blade right over, making contact between (B) and (C), thus short-circuiting the field, resulting in a collapse of the voltage which will cause the contact (B) to return immediately to contact (A), the machine then building up its voltage again, the same sequence of operations being followed as already described.

Fig. 6 shows the same arrangement, but with a combined voltage and current regulator where the additional contact is added.

An Interesting Design of Regulator

An interesting design of regulator is illustrated in Fig. 7. In this case the internal blade is provided with an electromagnet which moves longitudinally through the core. This regulator does not incorporate an automatic cut-out, and acts as an output regulator only. Contacts (*a* and *b*) are on the left and the compensating contact is on the right.

In this case the total battery current is not taken through the regulator, a proportion only being taken through a shunt. The value of the shunt can be changed at will to obtain any required characteristic. If the shunt has a low resistance value in comparison with the series coil, a small amount of current will flow through the coil, and vice versa.

The incorporation of the shunt makes it possible to remove a battery without fear of serious trouble.

Useful Purpose of Series Coil

The shunt coil is the main factor in determining the operation. The series coil protects the machine from overload if the battery is badly run down.

Adjustment of this type to a regulator is obtained by varying the pressure of the spring and of the compensated contact.

THIRD-BRUSH REGULATION

The third-brush method of regulating the current output of car lighting dynamos has been very considerably used. Although to some extent superseded by the compensated voltage control dynamo, as described in the preceding paragraphs, there is a very considerable number of cars fitted with dynamos of the third-brush type.

The Principle of Third-brush Regulation

The regulation of output in the case of a third-brush dynamo is based upon the armature reaction or field flux distortion.

A typical third-brush dynamo is illustrated in Fig. 8. The dynamo is fitted with positive and negative main brushes, but in addition a third brush is also fitted which, in the case of the dynamo illustrated, is on the left of the main negative brush. This third brush becomes the negative terminal of the field system, the other end of the field being connected to the dynamo positive terminal through a field fuse.

Under conditions of low-speed operation the armature current will be small. The field flux will take an almost direct path from the north to the south field pole. The current-carrying conductors under this condition will be in the main those conductors which are situated between the main positive brush and the third brush. As speed increases the armature flux will be distorted in the direction of rotation and the effect of this distortion is to weaken the flux between the positive main brush and the third brush, this weakening of field density being accompanied by a corresponding fall of voltage.

Thus, the normal tendency for the increased armature speed to produce increased voltage is compensated by the weakening of the field, which tends to decrease the voltage.

In actual practice third-brush dynamos are designed so that at low speeds the effect of armature reaction is less than at increased speeds. When the car is first started the charging rate will increase with the increase of speed until a certain r.p.m. has been reached ; after this the current output remains approximately constant up to a further given speed. When this speed limit is reached the effect of armature reaction is greater than the effect of increasing speed, with the result that further speed increases result in an actual decrease of charging rate.

Typical Example of Third-brush Dynamo

A typical example of a third-brush dynamo at various speeds is as follows:

2 amps. at 500 r.p.m.
7 amps. at 750 r.p.m.
10 amps. at 1,000 r.p.m.
12 amps. at 1,500 r.p.m.
11 amps. at 1,800 r.p.m.
10 amps. at 2,000 r.p.m.
8 amps. at 2,300 r.p.m.

It will be seen from this example that third-brush regulation is not so sensitive as regulation by electromagnetic means. The latter type of regulation can be designed to keep the voltage and current regulation within strict values. The third-brush dynamo, however, has the merit of

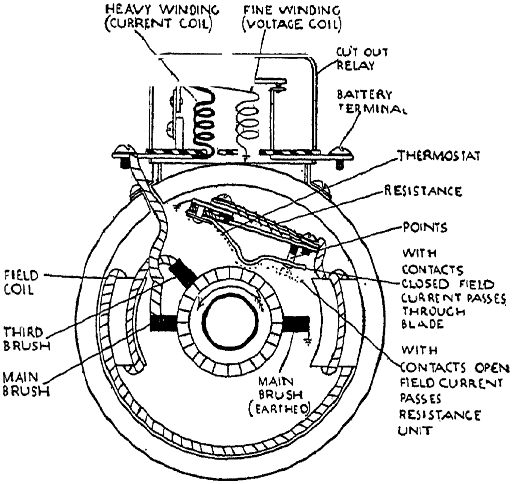


Fig. 9.—DIAGRAM OF A DYNAMO WITH A THERMOSTAT

The thermostat is mounted at the commutator end of the dynamo and enables the third-brush to be adjusted to a higher charging rate.

simplicity and it has proved itself in service to be a very satisfactory method.

Adjusting the Output of Third-brush Dynamos

The output of third-brush dynamos can be adjusted by alteration of the third brush on the commutator. To increase the output the brush should be moved in the direction of rotation. To decrease the output the movement should be in the opposite direction.

It will have been noted that the third-brush dynamo regulates the *current* output, since it is the value of charging current flowing through the armature winding which produces the distortion of the field for regulation. It is important, therefore, to ensure that the charging circuit should not be open-circuited by the removal of the battery and the dynamo operated under this condition, since in these circumstances the machine would build up a high and possibly dangerous voltage. Whenever the battery is disconnected either the field fuse should be removed or the main dynamo terminal should be earthed. Most third-brush dynamos are fitted with a field fuse.

With third-brush regulation there is a tendency for the charging rate to increase as the battery becomes fully charged. This is due to the rise in the battery back e.m.f., this rise causing an increased dynamo voltage which causes a corresponding increase in the current in the field coils.

Thermostat Control

A thermostat is frequently used in addition to the third brush. The use of a thermostat enables the third brush to be adjusted to a higher charging rate than if no thermostat were fitted, thus permitting a heavier charge to the battery on initial starting. The unit acts as a protective device as well as an output regulator and prevents overcharging of the dynamo.

Fig. 9 illustrates a dynamo fitted with a thermostat mounted at the

commutator end of the dynamo, where it is affected by the internal heat of the machine. The thermostat consists of a resistance unit and a set of contact points. The lower contact point is mounted on a bi-metal strip. At a certain pre-determined temperature the thermostat blade will warp, and at a given internal temperature the contact points will automatically open, thus inserting the resistance into the field circuit, which will decrease the charging rate. With the contact points closed the full current will pass through the thermostat blade. With the contact points open the full current will pass through the resistance unit. These resistance units vary in size, depending upon the design and the characteristics of the dynamo.

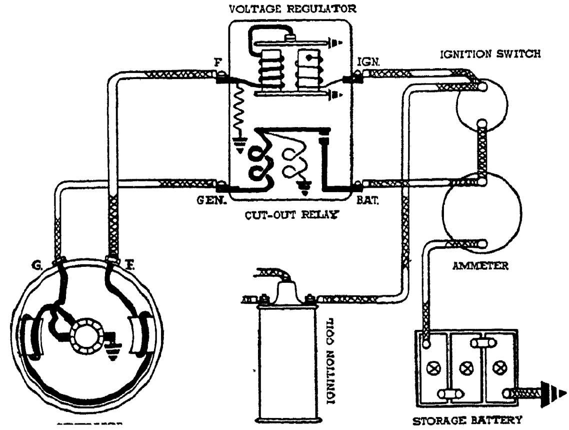


Fig. 10.—Voltage regulator circuit (fixed third-brush type) as fitted to Chevrolet cars

The contact points thus open when the current output is heavy and serve to decrease this output by approximately 40 per cent. The contact points return to their normal position immediately the temperature of the dynamo becomes normal. The thermostat unit is entirely automatic in action and requires no special attention in service other than occasional cleaning of the contacts.

Condition of Contacts

The condition of the contacts on the thermostat is of particular importance with this type of machine. If they become dirty or pitted, it will result in a low voltage and low output, a late cut-in, and an under-charged battery.

Although a burnt-out or open-circuited resistance will give a correct charge at low speeds, erratic conditions will be experienced at medium speeds because of the failure of the field thermostat to operate correctly.

If the resistance increases by a partial open-circuit, it will result in low voltage and output and no charging of the battery.

Conversely, in the event of the resistance increasing there would be a high voltage and output.

Rapid Test for Controller Fault

A rapid test for controller fault is to remove the battery lead, whilst engine is at a low–fair speed, and place it on the next cell, thus reducing a six-cell battery to a five-cell. The output should immediately increase. This gives a fair idea of the controller's action.

Manually Controlled Resistances

Certain designs of dynamo have a resistance unit, fitted inside the dynamo at the commutator end, which can be manually operated and inserted in the field circuit of the dynamo in order to decrease the maximum current output when required.

Such a dynamo when associated with third-brush current regulation gives both high and low outputs and a wide range of output adjustments. It is particularly applicable to vehicles which are operated almost entirely in the daytime, when very little charging current is required.

In cases where a vehicle is driven for any appreciable periods at night with the normal lamp load, the full capacity of the dynamo can then be obtained. In the same way the design is suitable for adjusting the output to a low value for summer running and a high value for winter running.

Lamp-load Control

Certain developments have been made in the provision of a special type of dynamo for commercial-vehicle work. In this case normal charging rate is obtained during daytime operation when no lamps are used. When the lights are switched on, the current used for lighting is passed through an additional set of field coils on the dynamo, the output itself being proportionately increased under night-driving conditions.

SELF-STARTER OVERHAUL

WHEN a car is brought into a garage with a faulty self-starter, certain tests should be made before removing the starter from the engine.

Open Circuit or Defective Battery

If the starter refuses to move at all, an open circuit in the starter or starter wiring is indicated, or possibly a flat or defective battery. This can be easily checked by switching on the lights; if the lights appear bright as normal, press the starter switch and observe whether this has any effect on the lights. If they do not dim slightly, then there is no circuit through the starter. A defective battery can also be checked by taking a reading of the specific gravity. If it is below 1·175, the battery is discharged and should be recharged. A continuation of the "lights" test is if the lights return to normal immediately, it is something outside the battery itself. If the lights remain dim or slow in coming up, the battery is flat—perhaps through a faulty starter.

Battery Connections

Next check the battery earth connection at the chassis, and clean and tighten if necessary. Check the battery terminals and make sure they are not corroded.

Starter-motor Switch

If no fault is found in the battery or the wiring to the starter motor, remove the starter-motor switch and examine the contacts, which should be clean and not corroded.

The switch can be tested by means of a low-reading voltmeter having a maximum reading of 3 volts,

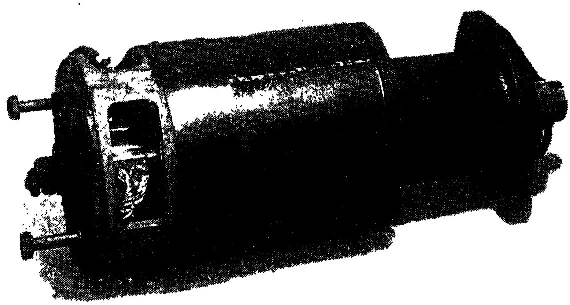


Fig. 1.—STARTER MOTOR READY FOR DISMANTLING
Showing retaining bolts removed.
(*By courtesy of Messrs. Shaw & Kilburn.*)

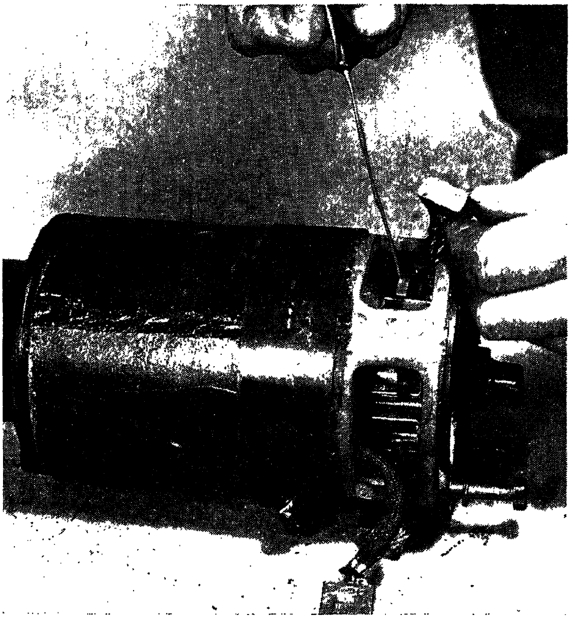


Fig. 2.—EXAMINATION OF BRUSH GEAR
Showing method of holding up retaining spring.
(*By courtesy of Messrs. Shaw & Kilburn.*)

which should be placed across the switch terminals, at the same time pressing the switch to the "on" position. If a reading of ½ volt or more shows on the meter, the switch should be removed and its internal contacts examined and cleaned or renewed. If the meter is connected across the switch before it is operated, there will be the full voltage imposed on its movement, which will damage the meter, so care is needed to see that the switch is operated before connecting the meter, and also to remove the meter before the switch is released.

The same test can be applied to all the connections and the reading taken when the switch is pressed.

Jammed Pinion

It is worth considering at this stage the possibility of a jammed pinion. The failure of the pinion to engage with the flywheel can be caused by too much oil on the screwed sleeve, as this oil will pick up dust and grit from the road, causing the pinion to stick to the sleeve. A jammed pinion may be caused by a discharged battery which, whilst being strong enough to allow of the engaging of the pinion, is too weak to turn the flywheel, with the result that the pinion cannot be thrown out.

To free a jammed pinion, the engine should be put into gear and the car rocked, or if the starter is provided with a square on the armature shaft, the shaft can be turned by means of a spanner, which will cause the pinion to be forced along the screwed sleeve and out of engagement.

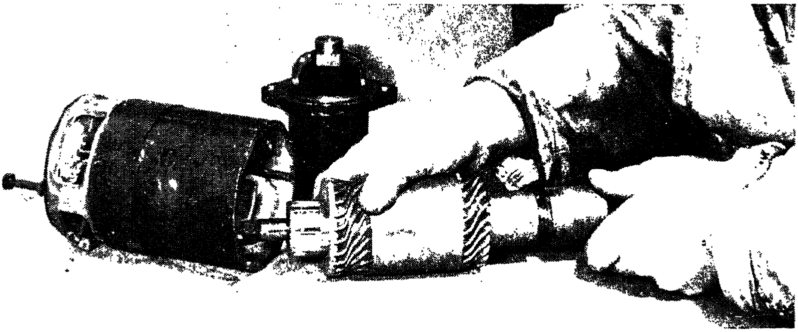


Fig. 3.—REMOVING THE ARMATURE FROM THE STARTER MOTOR
(*By courtesy of Messrs. Shaw & Kilburn.*)

Brush Gear

If the starter motor still does not start after making the above tests, it must be removed from the car. First examine the brush gear ; either the brushes may be sticking up in the brush holders or worn down so badly that the spring tension has become insufficient. An indication of bad brush contact is a badly burnt commutator. Should the brushes and commutator appear in order, an internal disconnection or break in the internal circuit of the starter must be looked for, and the starter motor should be completely dismantled.

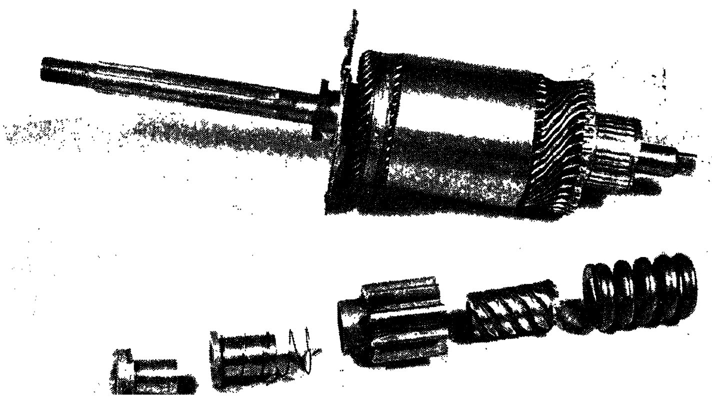
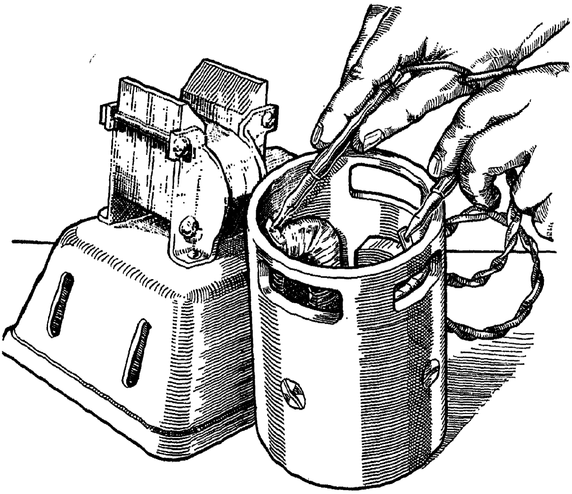


Fig. 4.—THE ARMATURE REMOVED
Showing also the bendix pinion and spring. (*By courtesy of Messrs. Shaw & Kilburn.*)



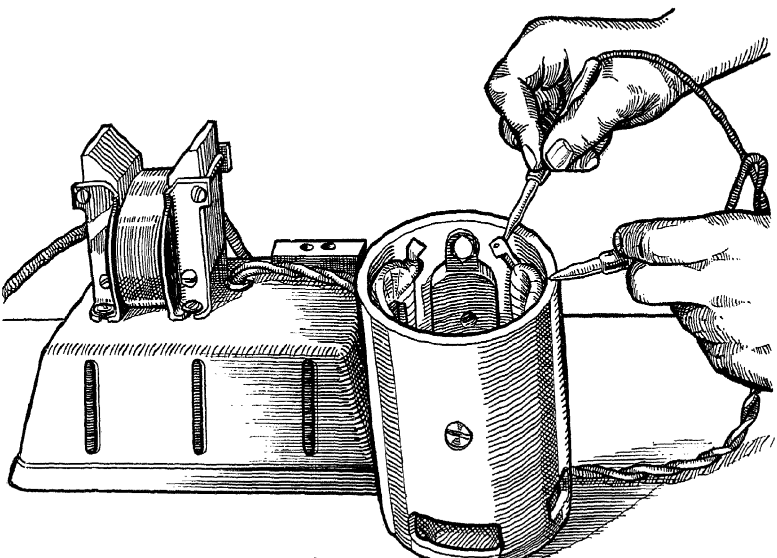
5.—TESTING FIELD COIL FOR CONTINUOUS CIRCUIT MEANS OF TEST LAMP

Testing a Starter Motor

The internal circuits of a starter motor can be tested either by using a test lamp or by the volt-drop method.

Field Coils—Test-lamp Method

To test the field coils for continuous circuit, place the test-prod leads on the field-coil leads as shown in Fig. 5. If the test lamp



'ig. 6.—TESTING FIELD COIL FOR EARTH

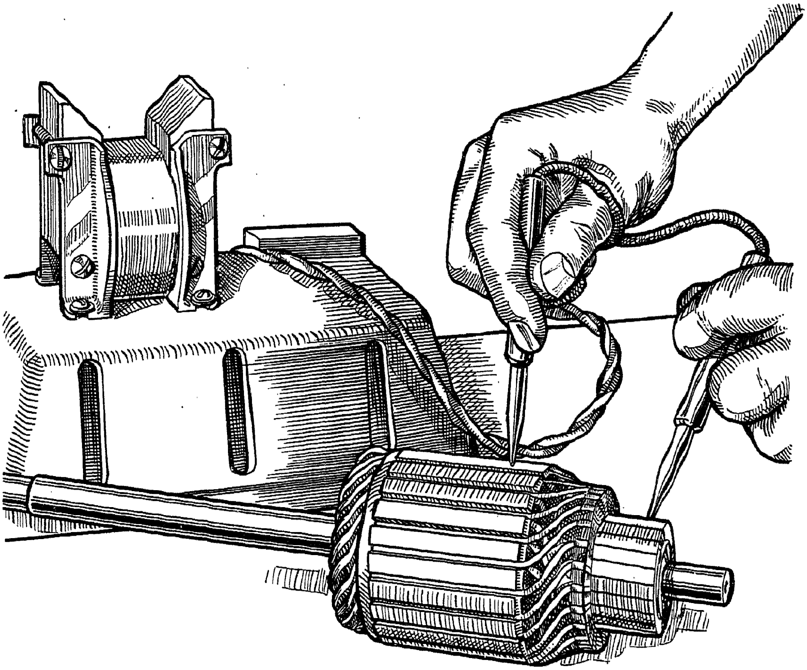


Fig. 7.—TESTING AN ARMATURE FOR EARTH

lights, the field coils are continuous, but if the test lamp does not light, there is an open circuit in one or both of the field coils. Each individual coil should be tested for equal resistance.

To test the field coil for earth, place one test-prod lead on the frame, and the other to the field-coil lead, as shown in Fig. 6. If the test lamp does not light, the field coils are O.K., but if the test lamp lights, one or both field coils are earthed.

To test a single field coil for earth, break the soldered connection between the two field coils and test each one separately, replacing the field coil that is earthed.

Field-coil leads should be examined at the point where they are soldered at the starting-switch terminal, to be sure that they are tight.

Field Coils—Volt-drop Method

The field coils can be tested by the volt-drop method by using a 12-volt battery. The leads from the battery with a $\frac{1}{2}$-ohm resistance in series are applied to the two ends of the field system. By connecting a voltmeter across each coil, a similar reading should be obtained from each one, but if a lower reading is obtained across one coil it will indicate a short

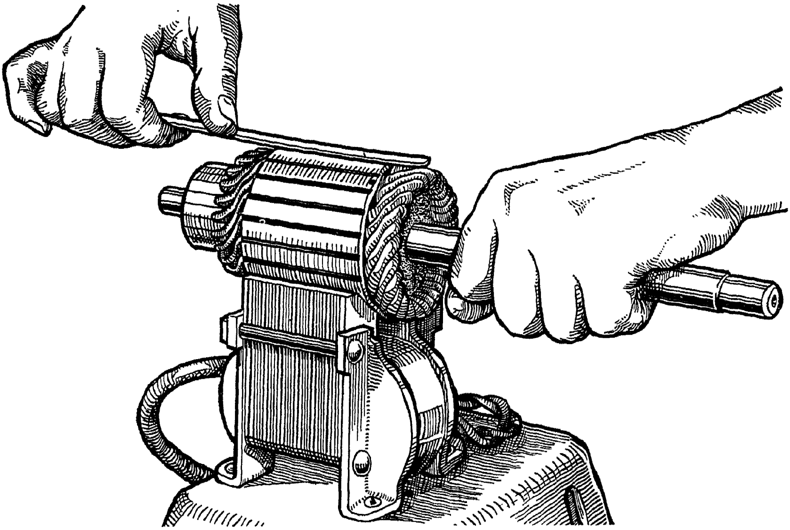


Fig. 8.—TESTING AN ARMATURE FOR SHORT-CIRCUIT

in that coil, or if one end of the field is connected to earth, it will also indicate an earth fault in that coil.

Another method of testing coils is by means of a 6-volt battery, a resistance and a 6-volt lamp, connected in series. The resistance should be of a suitable value to dim the lamp. Connect each field in series in turn; if they are in order, the bulb should dim equally still more.

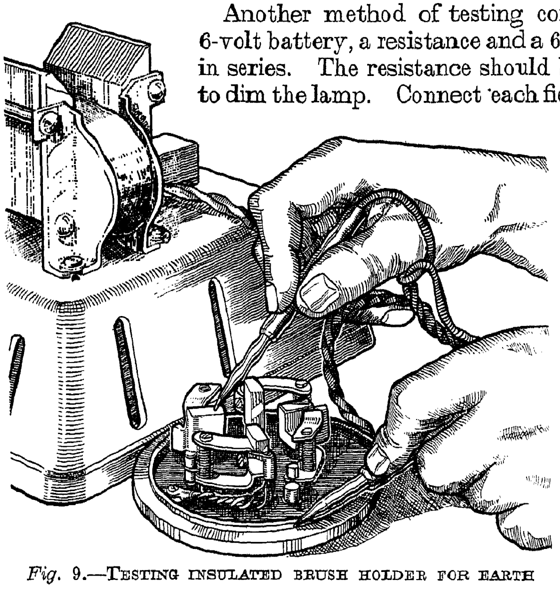


Fig. 9.—TESTING INSULATED BRUSH HOLDER FOR EARTH

Armature Testing—Test-lamp Method

The armature can be tested for earth by placing one test prod on the armature and the other on the commutator, as shown in Fig. 7. If the test lamp lights, the armature is earthed and should be replaced.

If the test lamp does not light, the armature is O.K.

Armature Testing—Volt-drop Method

To volt-drop test an armature, a large 12-volt starter battery is connected to two points on the commutator situated at 90° apart for a four-pole motor and 180° for a two-pole motor. In one of the battery leads a ½-ohm resistance capable of carrying 24 amps without overheating is inserted, and by connecting a low-reading milli-voltmeter across each pair of segments in between the battery leads, the same reading should show at each position. A loose connection at the commutator will show up as a higher reading on the milli-voltmeter, and the remedy is to resolder the connection.

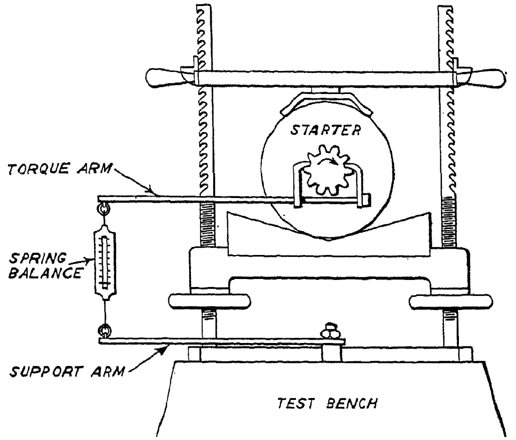


Fig. 10.—HOW A TORQUE TEST OF A STARTER MOT OR IS MADE

The starter motor is clamped rigid and the torque arm attached to the starter pinion as shown. On applying current to the starter, the reading of the spring-balance is noted. The arm can be used on the right-hand side of the bench for anti-clockwise rotation.

It is seldom for a short-circuit to develop in the armature unless it has been dropped, because there is generally only one turn per slot, but if a very low reading is obtained across a pair of segments the winding should be examined and any short in the winding will be easily seen, and when found, the shorting copper strips can be bent away from each other. If a short is not found in the winding then, the commutator should be carefully examined for any signs of copper bridging the two segments.

Another Test for Short-circuit

Place the armature on a Growler, and with a saw blade over the armature core rotate the armature and test (*see* Fig. 8). If the saw blade does not vibrate, the armature is O.K., but if the saw blade vibrates, the armature is short-circuited.

Inspecting Commutator

The commutator should be carefully examined for signs of roughness. If it is rough, turn down on a lathe until it is thoroughly cleaned up, and

sand off with 00 sandpaper. The micas between the copper segments should then be undercut.

Brush-holder Test

To test the insulated brush holder for earth place one prod of the testing set on the cover and the other on the brush holder. If the test lamp lights, the brush holder is earthed.

The brush earth-leads should be disconnected from the end frame and all terminals cleaned. Check the insulation of the brush to field-coil leads.

Repairs

When the fault has been located and is found to be in the armature or field coil, it may be necessary to rewind these components. Full particulars regarding rewinding will be found in a later section in this volume.

Torque Test

When the starter has been repaired it is advisable to give it a torque test to ensure that it develops the correct torque. This is usually done by mechanical means.

The mechanical method of torque testing consists of clamping the starter motor in a vice or test bench and fixing a torque arm to the motor shaft or pinion. The torque arm is a steel rod having a clamping device at one end to secure it to the motor shaft, and a hole in the other end for the insertion of the hook of a spring-balance. This arm extends 12 in. from the centre of the motor shaft to the hole for the spring-balance. The other end of the balance is attached to a firm support directly underneath.

The starter motor is connected up to a battery which is known to be in good condition, and the pull on the spring-balance is noted. If the spring-balance shows a reading of 12 lb., then the stalled turning torque will be 12 ft.-lb., and this reading is compared with that issued by the makers of the motor under test. Alternatively, the test result can be compared with another motor of the same type which is known to be in good condition.

THE FORD ELECTRICAL SYSTEM

By J. W. SANDERMAN, A.M.I.A.E.

IGNITION

IN overhauling the distributors there are one or two points which require particular care.

The cam used on current 8-h.p., 10-h.p. and 24-h.p. distributors is formed integral with the shaft and advance mechanism yoke and, therefore, it is not possible to alter the timing by means of cam repositioning. The drive gear must be set so that the offset drive slot is in the correct position for engaging the distributor shaft. The correct position is such that when standing at the near side of the engine with No. 1 piston at T.D.C. on the firing stroke and looking down on the drive, the slot is sloping forwards at an angle of 45° with the largest D-shaped portion facing rearwards. On earlier models the cam is detachable and it is not necessary to observe these drive gear positioning precautions.

When these distributors are dismantled it will be noticed that the two advance mechanism springs are of different sizes, and in no circumstances should these be changed for other sizes, the calibrated difference determining the correct slope of the ignition advance curve.

The form of the automatic advance curve is extremely important if satisfactory results are to be obtained, and should for some reason the advance be incorrect, no attempt should be made to alter the tension of these springs by bending of the anchor arms or other means.

Although these springs are supplied for service, if renewals are required it often is wisest to replace the complete advance assembly as, in addition, when this is

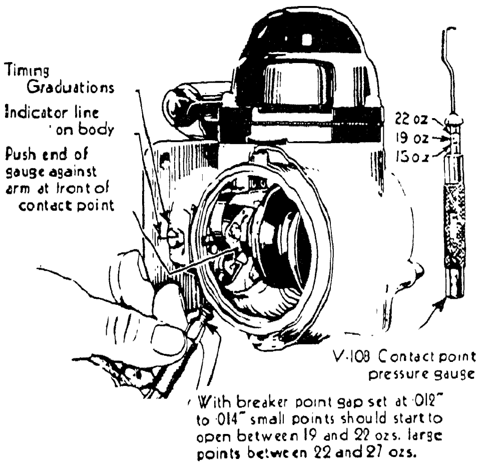


Fig. 1.—TESTING CONTACT-BREAKER SPRING TENSION

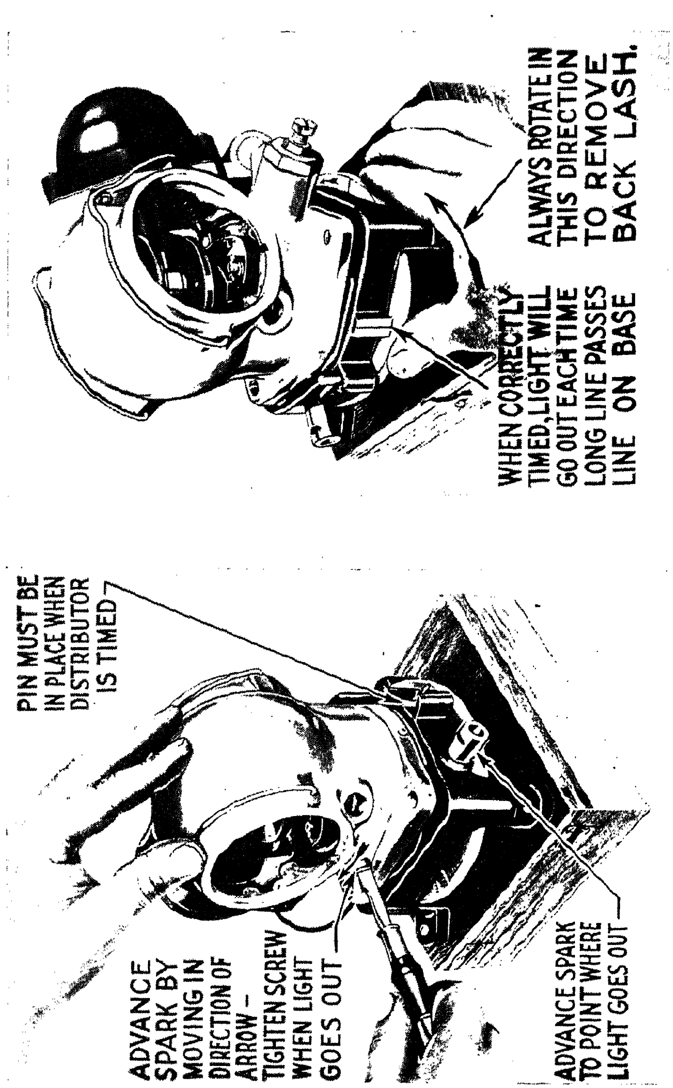


Fig. 2.—Timing V-8 distribution on special timing fixture

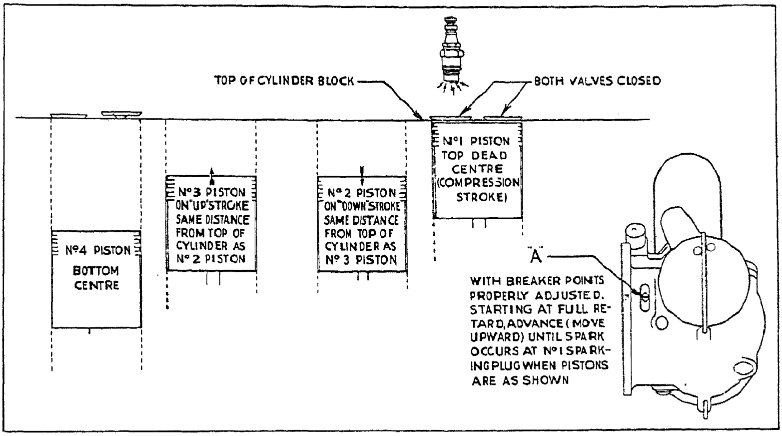


Fig. 3.—METHOD OF SETTING IGNITION ON V-8 ENGINES WHEN NO TIMING FIXTURE IS AVAILABLE

required some wear will probably have taken place at such points as the governor-weight pivots and pivot holes, which will also tend to alter the correct characteristics.

Testing Automatic Advance

When testing the automatic advance this should start at 400 r.p.m. of the crankshaft on V-8 engines, 700 r.p.m. on 24-h.p. engines, and 800 r.p.m. on 8-h.p. and 10-h.p. engines.

Testing Tension of Dual Contact-breaker Arm Springs

V-8 engines are very sensitive to correct ignition characteristics, and in addition to the above precautions the tension of the dual contact-breaker arm springs is extremely important. This tension may be tested by a special tension gauge, and with the later models having contact-breaker points approximately $\frac{3}{16}$-in. diameter, the spring tension should be between 22 oz. and 27 oz. The earlier models had contact points of a smaller diameter, and the breaker springs on these distributors should have a tension of between 19 oz. and 22 oz.

Setting Ignition Timing (V-8)

The initial setting of the ignition is also of extreme importance, and it is advisable to use a special electrical timing fixture which permits the distributor to be correctly timed whilst off the engine.

Should such a fixture not immediately be available, the ignition can be set (but not with the same accuracy) by bringing No. 1 piston nearly to the top of its compression stroke and then slowly turning the engine

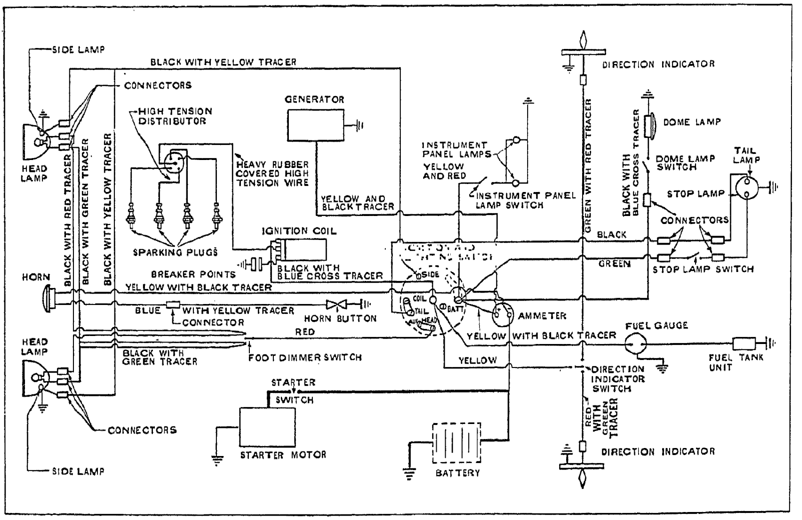


Fig. 3A.—WIRING DIAGRAM FOR FORD 8 H.P.

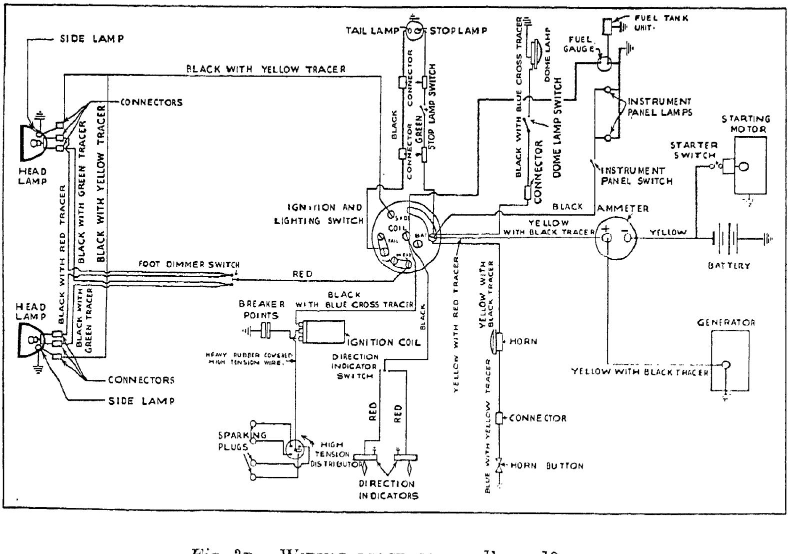


Fig. 3B.—WIRING DIAGRAM FOR FORD 10 H.P.

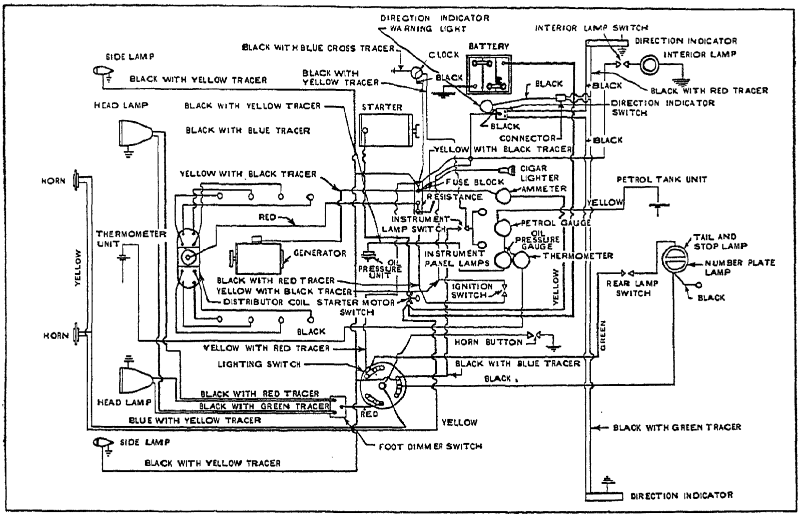


Fig. 3c.—Wiring diagram for Ford V-8 "22"

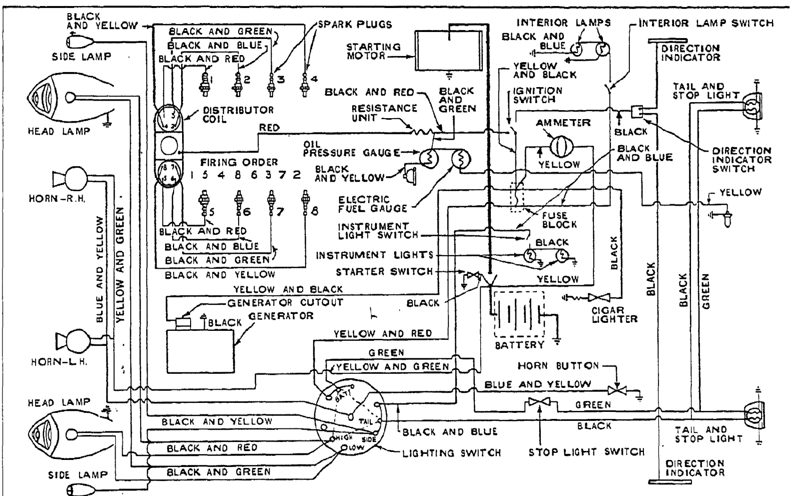


Fig. 3d.—Wiring diagram for Ford V-8 "30"

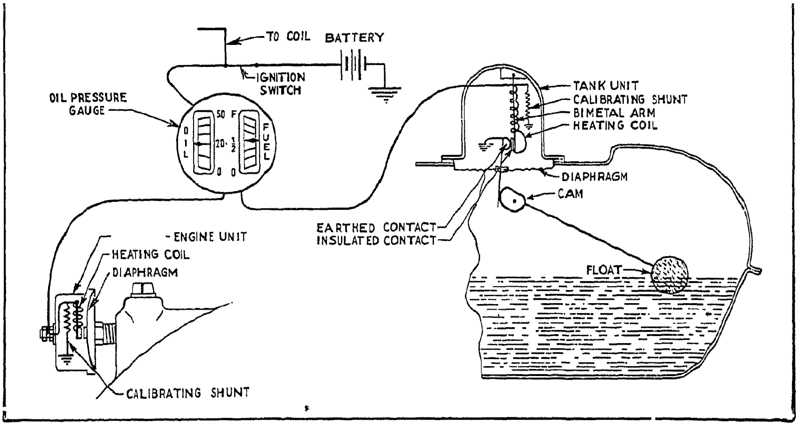


Fig. 4.—OPERATION OF OIL-PRESSURE AND PETROL GAUGES

until pistons Nos. 2 and 3 are an equal distance from the top of the cylinder block.

The advance adjustment on the side of the distributor should then be placed in its lowest position, and with the ignition switch "on" slowly moved upwards until a spark occurs at No. 1 sparking plug, when the adjusting screw should be moved upwards one additional graduation. This will give the initial setting of 4° before T.D.C.

The above method of setting the pistons of V-8 engines for ignition timing is, of course, best carried out before installing the cylinder heads, but is a method not recommended on any 4-cylinder models, as accuracy is not possible, due to the offset cylinders. The V-8 cylinders are also offset, but the relative positioning of the various pistons enables reasonable accuracy to be obtained by this method.

Timing Ignition on 4-cylinder Engines

All 4-cylinder engines are, however, provided with more positive means of setting the piston for ignition timing.

A timing pin is screwed into the front timing cover and under normal conditions projects outwards. When it is required to set the pistons for ignition timing this pin is unscrewed, reversed, and the plain portion inserted in the hole from which it has been removed.

If light finger pressure is applied to the pin and the starting handle is used to rotate the engine very slowly, it will be found that at a certain point the pin drops into a small recess. This recess is on the face of the camshaft gear, and when in this position indicates that number one piston is in the exact position for setting the distributor timing.

As the engine timing wheels are marked for correct mesh this method

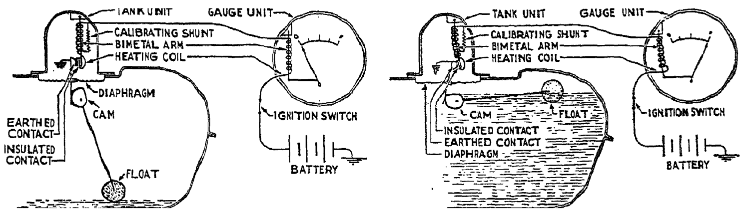


Fig. 5.—Operation of petrol gauge

gives great accuracy, but should the timing wheels not be correctly meshed the ignition timing would also be incorrect. This condition, however, would readily be apparent, as the valve timing would be at least one tooth out, which, combined with the consequently incorrect ignition timing, would give obviously unsatisfactory running.

Contact Breaker Correct Gap

It is, of course, necessary before making the above setting to see that the contact-breaker point gaps are set to the correct clearance of ·012 in. to ·014 in. on the earlier models, and ·014 in. to ·016 in. on later models.

This is an important point, as synchronisation of the two breaker arms controls the saturation period of the coil.

Particular care must be taken not to unduly bend or strain the contact-breaker arm springs, as this will alter the point pressure and possibly cause misfiring at high speeds.

Previous type distributors for the 24-h.p. engine should have a contact-breaker gap of between ·018 in. and ·022 in. Early-type 8-h.p. and 10-h.p. distributors not provided with an adjusting index should also have a similar contact-breaker gap, which differs from the later distributors provided with an adjusting index having a gap of between ·010 in. and ·012 in. This latter setting is also used on current type 24-h.p. distributors.

Fitting Starter Motors

Due to various changes in design of starter motors, it is possible to fit a new 8-h.p. or 10-h.p cylinder block or a reconditioned engine on which it will not be possible to install the original motor. To overcome this difficulty a number of adaptor plates are available to enable the original motor to be used, and it is advisable when ordering a new block or reconditioned engine to state with which type of starter motor it is intended to be used.

V-8 engine-starter motors also underwent a change, so that if a change is necessary or a flywheel ring gear has to be renewed, the correct parts must

be obtained. Early starter motors had a drive pinion with 10 teeth which meshed with a flywheel ring gear having 112 teeth, while the later motors had a pinion with 9 teeth meshing with a ring gear having 144 teeth.

Electrically Operated Oil Gauges

The oil gauge on both 22-h.p. and 30-h.p. V-8 cars is electrically operated, an electrical pressure unit being screwed into a connection with the oiling system at the rear of the cylinder block. These units, however, cannot be changed from one type of engine to the other, as they operate on different principles. That on the 22-h.p. engine has two contact points which are held apart by the oil pressure, so that if oil pressure fails the points come together, so completing the electrical circuit and operating the warning light on the instrument panel.

On the 30-h.p. engine the points are held in contact by the oil pressure, so permitting a current to flow through a heating coil surrounding a bi-metal arm which when heated tends to separate the points. A similar system is incorporated in the instrument panel gauge to which the engine unit is connected, so that the amount of current, degree of heat in the bi-metal arm, and amount of arm deflection is reproduced in the gauge and indicated by the pointer.

It should be clearly understood that the oil-pressure gauge system on the 30-h.p. V-8 records the pressure in lb. per square inch on an instrument panel gauge, whereas the system on 22-h.p. V-8 engines merely acts as a warning when the pressure drops to a dangerous degree; usually about 7 lb. per square inch.

Testing Gauges for Faulty Operation

Should either of the engine units be suspected of faulty operation, the simplest method of ascertaining this is to temporarily replace it with a new one. If a new unit is not available a mechanical type pressure gauge can be inserted in its place to check if the normal oil pressure is being obtained; this should be between 25 lb. and 30 lb. per square inch at normal working temperatures.

To test the instrument panel unit on 30-h.p. V-8 cars it may be disconnected from the engine unit and a temporary lead used to pass current direct from the battery to the gauge. Watch carefully that the current is not applied too long but only sufficient to see that the gauge needle rises in the normal manner. If incorrect calibration is suspected it is advisable to change the complete gauge.

BATTERIES AND BATTERY CHARGING

By EDWIN H. WRIGHT, F.R.S.A., F.T.S.

THE subject of choosing the correct type of plant for the efficient charging of secondary cell batteries, commonly known as "accumulators," is of extreme interest besides importance.

In order that the reader may obtain a better grasp upon the underlying principles described in this article, it may be permissible to first consider briefly the battery itself: its origin, construction, and the manner in which it functions.

Types of Battery

There are only two types of secondary cell in general use at present. First, and practically universal in use, is the type known as "lead-acid," whilst the other type, attributed to Edison, is known under various names, including "nickel-iron," "alkaline," or "NiFe." As the latter has still some distance to progress before becoming a serious rival to the lead-acid type, and is seldom met with in normal charging stations, our considerations will be confined to lead-acid batteries.

Construction

Manufacturing methods are obviously outside the scope of this article, but the form of construction in which the battery reaches us may warrant a brief description.

In its usual form it consists of a rectangular container of insulating material, divided internally into cells; each cell housing its quota of plates and electrolyte (dilute sulphuric acid) sufficient to ensure an output voltage of 2–2·2 on completion of charge; the current rating depending upon the active surface area

Fig. 1.—POSITIVE AND NEGATIVE PLATE GROUPS OF A BATTERY CELL

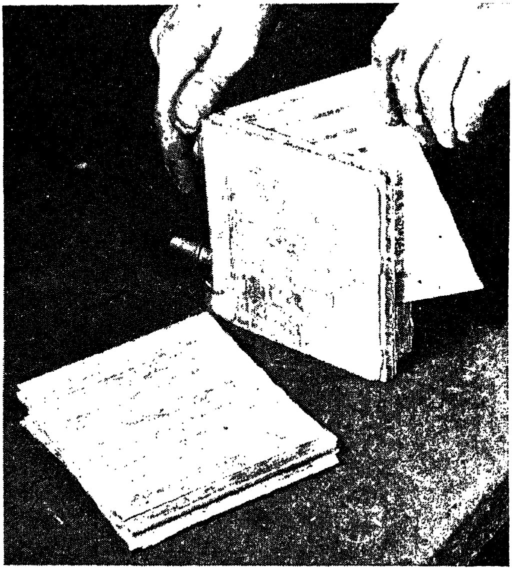


Fig. 2.—THIS SHOWS THE THIN WOODEN SEPARATORS WHICH ARE PLACED BETWEEN THE POSITIVE AND NEGATIVE PLATES OF A BATTERY CELL

of the plates, otherwise upon their size. These 2-volt cells are connected in series, so that their voltages are added together. Thus, a 6-volt car battery embodies three cells in its container, whilst a 12-volt battery comprises six cells.

Each cell has its own series of positive and negative plates, arranged in two groups respectively; each group being individually connected together, metallically, inside the cell. The positive group is kept insulated from the negative group by thin separators of celluloid, wood, or other insulating medium. The electrolyte, which should be a high-quality acid such as B.A.A., completes the contents of the cell, which has a conductor from each group of plates, led to the outside for connection to other cells, or to the load, i.e. an exterior circuit, or to the charging equipment.

The plates generally consist of lead frameworks of grid construction, the interstices of which carry the active material or paste. Under normal conditions in a new battery, the positive paste consists almost wholly of peroxide of lead (PbO_2), whilst the negative plate is of more or less pure lead. Both positive and negative plates have acquired their characteristic spongy paste formation during process of manufacture, and this is more readily acted upon by the electrolyte. It will be noticed that in the new or charged condition, the positive plates will be of dark brown or chocolate colour, whilst the negative will be light grey. The colouring should be smooth and uniform, any tendency to roughness or patches of whitish colour indicating the first stages of sulphation ; which should be removed at once by prolonged charging at a low rate.

Action of Battery

Assuming the battery to be in good condition, its action is as follows : If the two groups of plates be joined together by their outer con-

ductors or terminals through an exterior load or resistance, a current will flow from the positive terminal, through the load, to the negative terminal, and through the electrolyte, completing its circuit back to the positive.

This discharging action is both electrolytic and ionic. Hydrogen ions go to the positive plates, and combine, when neutralised, with the oxygen present in the peroxide of lead, thus forming lead monoxide ; whilst at the negative plates, sulphur and oxygen ions combine with the lead, forming lead sulphate. The lead monoxide at the positive plates easily combines with the sulphuric acid electrolyte, forming lead sulphate and water, hence both sets of plates become partly covered with lead sulphate ; a small measure of water is formed, and some of the sulphuric acid is used up. This results in obvious dilution of the electrolyte and a fall in cell voltage ; in other words, the cell has been discharged to an extent depending upon how far the above action has been allowed to proceed.

The chemical aspects of the re-charging process need not be touched upon here. Suffice it to say that at the end of a charging period, when efficiently carried out, both sets of plates and the electrolyte will be restored to their original condition ; a reversal of the discharge having taken place, be it noted, by chemical action, of which the charging current is simply the cause. Contrary to general belief, electricity is not merely pumped into the battery, stored by it, and taken out when required. The battery stores chemical energy upon charging, and reconverts this into electrical energy upon discharge.

Fig. 3.—THE TWO GROUPS OF PLATES AND SEPARATORS BEING FITTED COMPLETE INTO A BATTERY CASE

Charging

The reader should now be better able to understand why an alternating current is useless for direct connection to batteries for the purpose of charging. As alternating current changes its polarity from positive to negative and vice versa at a frequency of anything from 50 to 100 times per second, any chemical change brought about within

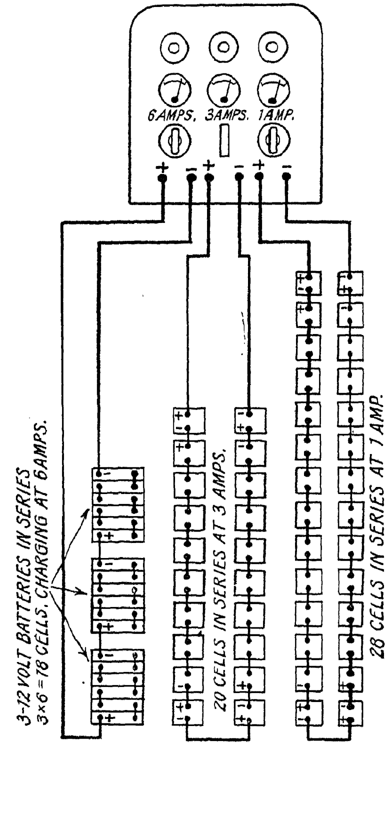


Fig. 4.—SELECTING A SUITABLE BATTERY CHARGER

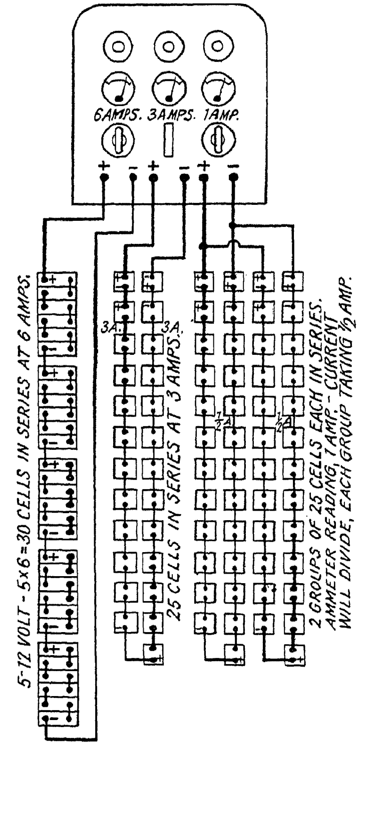


Fig. 5.—TYPICAL EXAMPLE OF SERIES AND PARALLEL CHARGING

Assume that the following number and size of cells are to be charged: (1) 3 12-volt car batteries (18 cells) at 6 amps.; (2) 20 radio cells at 3 amps.; (3) 28 radio cells at 1 amp. The maximum number of cells is 28, and therefore the maximum voltage of the charging plant will need to be 28 × 2·5 = 70. In practice, it will be preferable to use a 75-volt plant, which is standard. A suitable plant would, therefore, be one with three circuits, giving charging rates of 6 amps., 3 amps., and 1 amp., and a maximum voltage of 75.

The above picture shows a 3-circuit charger with outputs of 6, 3, and 1 amps. at a maximum voltage of 75. There are 50 cells for charging on the 1-amp. circuit. These, if put on circuit in series, would need 50 × 2·5 = 125 volts, considerably above the maximum voltage of the charger. The safe solution to the problem is to divide the 50 cells into two groups of 25 cells each in series and connect each group across the 1-amp. terminals in parallel, as shown above. Each group will be charged at ½ amp.

the cell by a positive impulse would be immediately cancelled out by the following impulse of reverse polarity. The net result, so far as chemically re-forming the plates is concerned, would be nil.

It therefore follows that direct, not alternating, current must be used, and as the majority of power-supply authorities distribute alternating current only, we must find suitable equipment to convert this into direct current; which flows in one direction only, and will, therefore, induce the required chemical change in the battery without interruption or reversal.

The Charger

This brings us to the controversial yet interesting subject of chargers; a subject to which those interested in battery-charging should devote full consideration. The charger is the heart of any battery-charging plant, and its responsibilities include not merely the converting of alternating into direct current, but also the mechanical efficiency of the plant; its reliability, convenience in operation, and, perhaps most important of all, its running costs—this last being directly governed by its electrical efficiency. Attention paid to these points will make all the difference between success or failure, both technically and financially, in the operation of a battery-charging or service station.

Types of Charger

There are numerous types of charger, which may be conveniently divided into the following classes:

(1) Commutating rectifiers and motor-generators, which depend for their functioning upon motion derived from the forces of electromagnetism.

(2) Electrolytic and ionic, the action of which is electro-chemical.

(3) Thermionic valves, which derive their direct current by means of a stream of negative electrons attracted to a positively charged plate, the electrons being first released by heat from a distintegrating filament.

(4) Metal rectifiers, the action of which is purely electronic in the case of copper-copper-oxide; but is definitely ionic or electrolytic in the cases of so-called "metal" rectifiers constructed from magnesium or copper-sulphide.

THE COMMUTATING RECTIFIER

Turning to chargers falling into Class 1, the functioning of which is dependent upon motion, there appear to be only two of these types at present surviving. One is the commutating rectifier and the other the motor-generator.

The commutating rectifier is in effect an alternating-current motor which carries a four-segment commutator upon its rotating armature-shaft. The segments are disposed around the circumference of the commutator body, and are interconnected for correct functioning as follows (*see* Fig. 7):

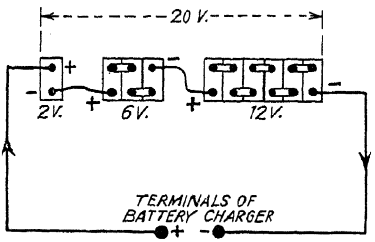


Fig. 6.—SERIES METHOD OF CONNECTING BATTERIES

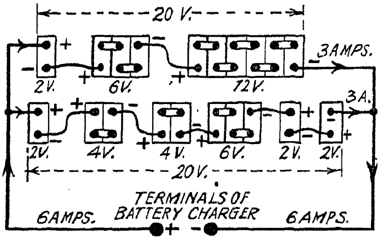


Fig. 6A.—SERIES-PARALLEL METHOD OF CONNECTING BATTERIES

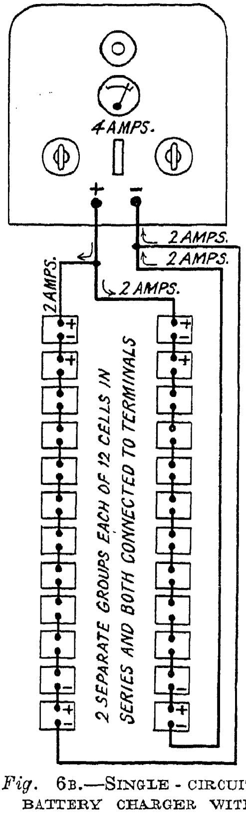


Fig. 6B.—SINGLE - CIRCUIT BATTERY CHARGER WITH OUTPUT OF 4 AMPS. WITH TWO GROUPS OF CELLS CONNECTED IN SERIES-PARALLEL

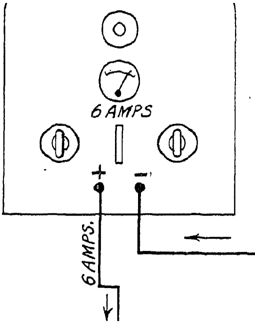


Fig. 6C.—SINGLE-CIRCUIT CHARGER OF 6 AMPS. OUTPUT WITH THREE GROUPS OF SIX CELLS CONNECTED IN SERIES-PARALLEL

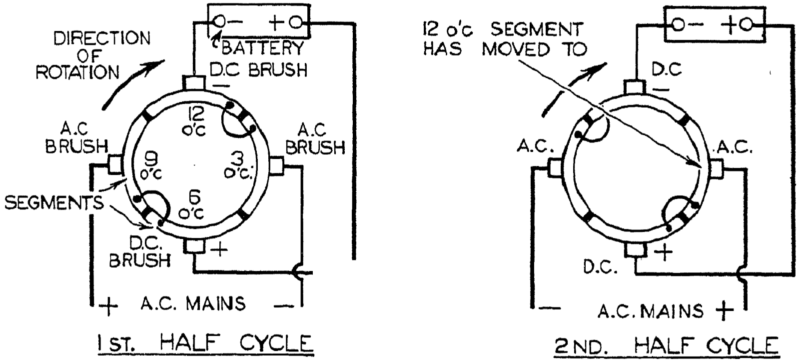


Fig. 7.—HERE WE SEE THE PRINCIPLE OF OPERATION OF A COMMUTATING RECTIFIER

Imagine the flat end-section of the commutator to represent a clock dial. Four copper segments are embedded in the body at the hours of 12, 3, 6, and 9.

The 9-o'clock segment is directly connected to the 6-o'clock segment—and through brush gear to one of the alternating-current mains terminals, which we will assume at the moment of description to be at its positive half-cycle.

The 3-o'clock segment is directly connected to the 12-o'clock segment,

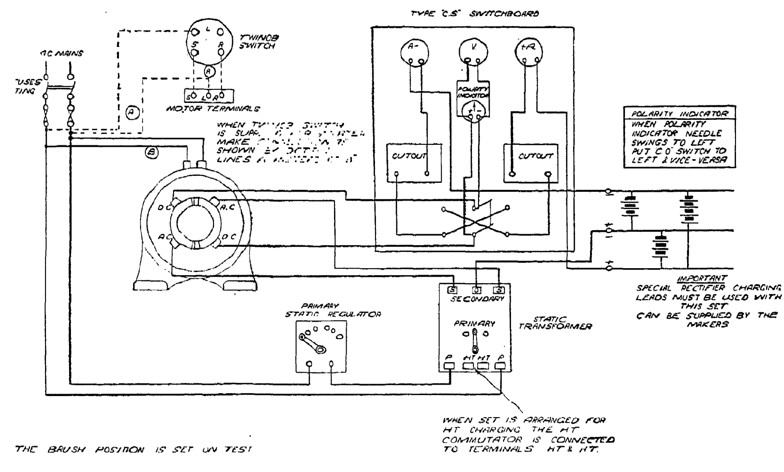


Fig. 8.—HERE WE SEE THE CONNECTIONS OF A COMMUTATING RECTIFIER, FOR 3-BUSBAR CONSTANT-POTENTIAL CHARGING (*Crypton Equipment, Ltd.*)

and through further brush gear to the remaining mains terminal which is (at the moment) negative.

A collecting brush bears upon the commutator segment 6, and a lead is taken from this carrying the current which is of positive polarity, whilst another lead, from a brush bearing upon the segment at 12 o'clock, constitutes the negative. Brushes 6 and 9 are now positive, and brushes 3 and 12 are negative.

Now, if the motor be started so as to rotate the commutator in a clockwise direction at a speed of one quarter of a revolution for every change of polarity of the mains, by the time the segments 12 and 6 have advanced to contact with brushes 3 and 9, the mains polarity has reversed, and brush 9 which had previously been positive is now negative and brush 3 is now positive. Although, however, the mains half-cycle change has taken place, brush 12 remains negative and brush 6 positive.

It is clear, therefore, that the lead from brush 6 is always positive, whilst that from 12 is always negative. Full-wave rectification has been accomplished.

THE MOTOR GENERATOR

This brings us to consideration of the above equipment, which is probably next in order of importance for battery-charging purposes.

As is doubtless already known to the reader, it comprises an alternating-current motor, mechanically coupled to a direct-current generator or dynamo ; which latter, upon being driven by the motor, discharges a direct-current output through the batteries.

IONIC RECTIFIERS

It is a well-accepted theory, borne out in early battery-charging practice, that any rectifying apparatus dependent upon ionic or chemical action must be, by reason of its nature, largely dominated in life and performance by climatic conditions. Since water, in the form of vapour or damp atmosphere, often heavily charged with acid or other chemical fumes, is readily absorbed by the porous and hygroscopic elements of most electrolytic or ionic rectifiers, it follows that their original chemical formula cannot remain permanently unchanged. In due course they have been found to deteriorate owing to internal corrosion and chemical changes in composition caused by adsorption of exterior vapours. Especially is this so in tropical climates, or when installed within reach of the sulphuric acid fumes always more or less present in battery charging-stations.

The first rectifiers of this type generally consisted of two platinum or other metal electrodes in contact with a chemical solution contained within a semi-sealed jar constructed of insulating material. These were superseded later, by a somewhat similar arrangement, in which the

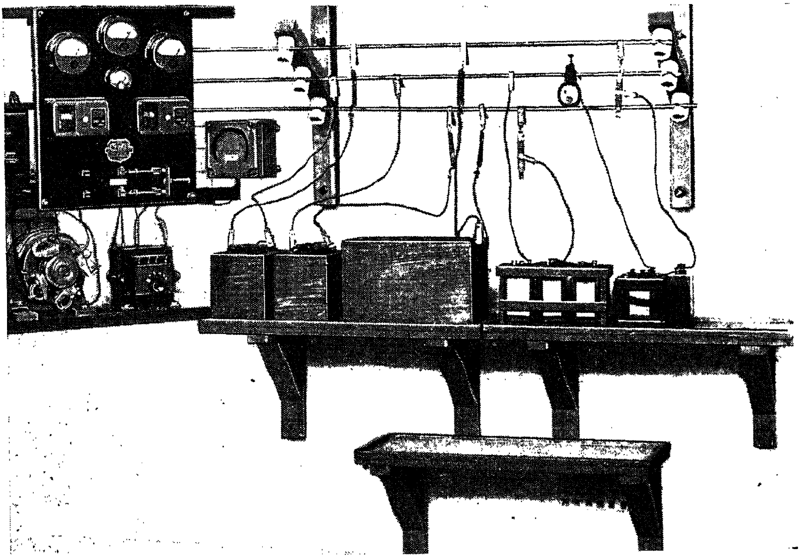


Fig. 8A.—A COMPLETE COMMUTATING RECTIFIER BATTERY-CHARGING INSTALLATION

The commutating rectifier is shown on the extreme left with the transformer next to it. It is charging the batteries by the constant-potential method. Note the three busbars across which the batteries are connected. The connections will be clear from Fig. 8.

(*Crypton Equipment,*'*L*

chemical solution was contained within a block of absorbent material; and these were probably the forerunners of the series of dry ionic and electrolytic rectifiers of foreign origin (often passed off as "metal" rectifiers), which may be purchased even to-day in this country. Rectifiers of the early type embodying electrolyte in liquid form are now quite obsolete, except, perhaps, in some cases of laboratory work.

THE THERMIONIC VALVE RECTIFIER

The valve rectifier may introduce itself to the reader in any one of three different forms, all enclosed within evacuated glass bulbs: either as mercury vapour, heated filament, or a combination of both. As the first-mentioned type will rarely, if ever, be met with in battery service work owing to its extremely low efficiency when used below half-load, it will be omitted from consideration.

The second and third types are, in principle, so similar to each other that for our purpose it will be convenient and permissible to deal with them as a single unit.

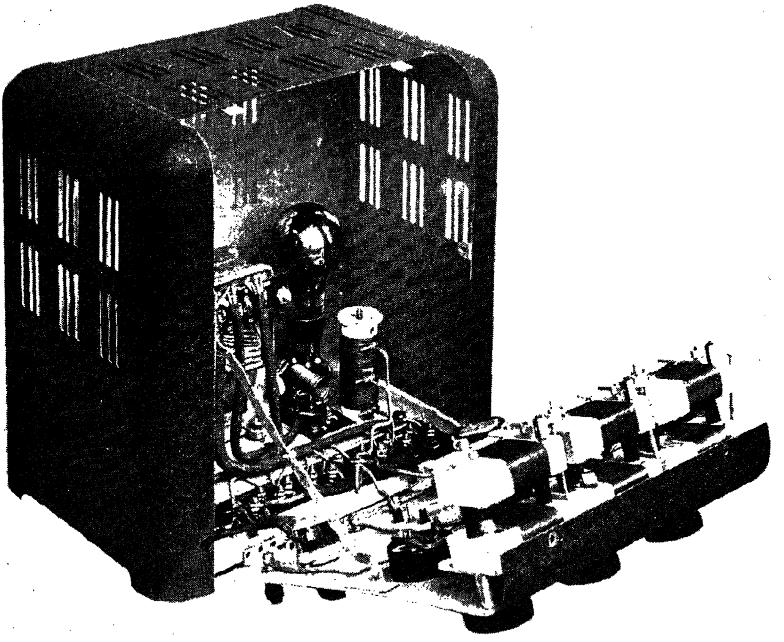


Fig. 9.—A 3-CIRCUIT BATTERY-CHARGING OXIDE-CATHODE RECTIFIER
Showing the interior components, including transformer and rectifying valve. (*Crypton.*)

Operation

In 1904, Professor Ambrose Fleming (since knighted) first put to practical use a previous discovery made by Thomas Alva Edison, pertaining to carbon or metal-filament lamps ; this was known as the "Edison effect." Edison noticed that after burning for some considerable time, a "shadow" or blackened image of the filament became imprinted upon the interior of the glass bulb.

Investigation followed, and ultimately proved this to be an actual deposit of the filament material emitted from it in the form of electrons, due to its disintegration by heat. The filament gradually "evaporates" in this way, which accounts for its cross-sectional area diminishing until its mechanical strength becomes insufficient to maintain cohesion. However, before this stage is reached, the filament generally fractures at its thinnest point, due to overheating, and its life is over. Given good conditions, and freedom from vibration or overload, the life of such a filament working at full emission may reach approximately one thousand hours or more.

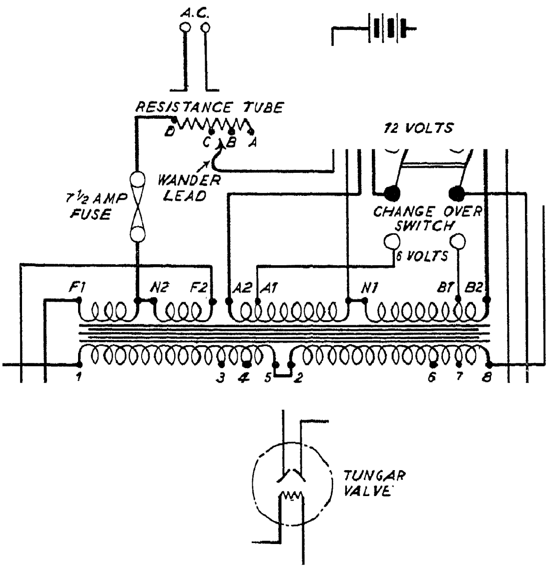


Fig. 10.—A TUNGAR VALVE CHARGER DESIGNED FOR CHARGING EITHER A 6- OR 12-VOLT MOTOR-CAR BATTERY

The change-over switch enables either 6- or 12-volt battery to be charged by changing the position of the switch.

Now, bearing in mind that (1) electrons are of negative sign: (2) that, as in magnetism, so in static electricity, unlike polarities or signs attract toward each other; and (3) that as a flow of electricity through a conductor is merely a flow or movement of electrons, Fleming correctly concluded that if this filament electron stream could be collected and conducted outside the bulb, around a completed exterior circuit, it would constitute a flow of direct-current electricity, and make possible the manufacture of static rectifiers at economical cost.

To this end, he constructed a lamp with a filament of low voltage, and inserted, near the filament, a plate or anode fitted with an exterior terminal. He then heated the filament by passing a suitable current through it, and connected the anode to one pole of an alternating-current supply of high voltage. The remaining A.C. pole was returned to the filament via a suitable current-limiting resistance, and polarity indicator.

Switching on the high tension (A.C.) in the anode circuit, he obtained just what he expected. The negative electron stream was attracted to the positive anode upon each positive half-cycle of the A.C., and pulses of current flowed through the exterior circuit accordingly. However,

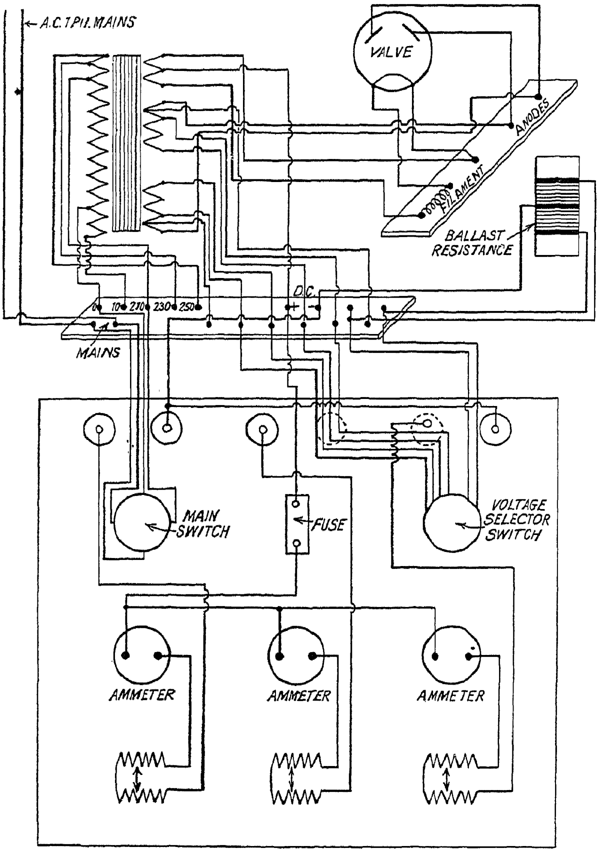


Fig. 11.—DIAGRAM OF CONNECTIONS FOR A 3-CIRCUIT VALVE BATTERY CHARGER

when the anode was negative, no current was indicated. Fleming thereby produced "one-way traffic" through the lamp, which thus became an electrical valve.

This valve (or rectifier) had no commutators, brushes, field-magnets, concrete bases, or moving parts. It was light in weight, small in bulk, and economical in cost; and its efficiency upon light loads proved to be considerably higher than that of the motor-generator, or any other form of rotary rectifying plant.

Types and circuits were soon designed, enabling full-wave rectification to be obtained, and these valves ultimately found their way into the specifications of commercial battery-chargers.

Life

Reverting to the life of the filaments in such rectifiers, it is generally agreed among users that filaments of the type in which electron-emitting substances (usually thoriated tungsten) are adsorbed or impregnated in the material, generally fail when the diameter, or cross-sectional area, has fallen by 7 per cent. to 10 per cent. of the original; whilst filaments of the type which carry an outside coating of emissive material can fail within

a few minutes, if conditions are such as to permit excessive emission. One thousand hours appears to be the generally accepted expectation of life.

Its efficiency as regards costs in running should be carefully considered. Like all electrical apparatus, none of which is perfect, it has some disadvantages and unavoidable losses. It must be remembered that costs of running are not entirely bound up within the supply company's quarterly account. Repairs and renewals, if not prevented at the outset, may become very heavy items.

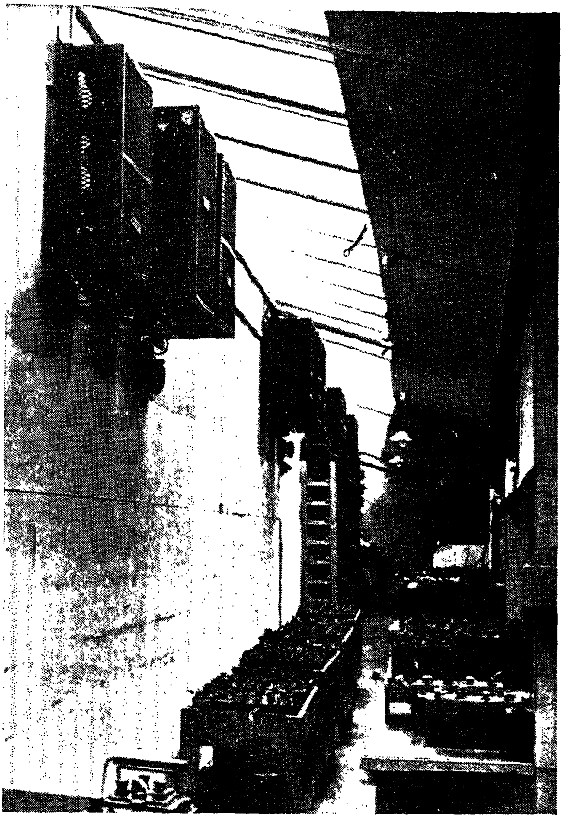


Fig. 12.—TYPICAL INSTALLATION OF SEVEN COPPER-OXIDE RECTIFIERS FOR BATTERY CHARGING (*Westinghouse Brake & Signal Co., Ltd.*)

THE COPPER-OXIDE RECTIFIER

This, a comparatively recent introduction, is becoming more widely known and used, as in course of time it becomes better understood.

Its origin is attributed to two American research workers, Grondahl and Place, and the principle is, in brief, based upon the fact that a current of electricity may pass through copper-oxide to copper, but will not pass (except in negligible quantity) through copper to copper-oxide.

Much development work has been conducted upon this property of a copper-oxide junction, and for some years past there have been large numbers of commercially manufactured types and sizes available for all purposes of rectification. An indication of the forms of construction may not be amiss, and will certainly assist the reader to form his conclusions

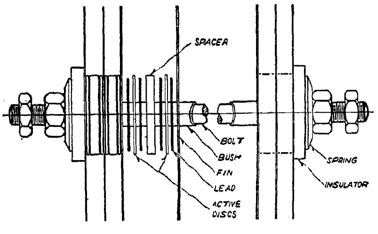


Fig. 13.—EXPLODED VIEW OF COPPER-OXIDE RECTIFIER, COMPRESSION CONTACT TYPE (*Westinghouse Brake & Signal Co., Ltd.*)

as to the worth of this newest of rectifiers.

Construction

Imagine a copper disc, approximately the size of a penny. Now if this be given a special heat-treatment upon one side only, that side will acquire a layer of copper-oxide, of thickness and quality in accordance with the degree of temperature applied, and the time or period of its application. Other processes are involved, but we are only concerned here with the basis.

It is at the junction of the copper and copper-oxide, where the one changes into the other, so to speak, that rectification takes place. The oxide is not sprayed, spread, or pressed into the copper, as many are erroneously led to believe. It is actually part of the disc.

The voltage safely accepted by such a disc may, according to design and process, be anything between 4 and 8, and the current-carrying capacity is governed by the diameter or area. Thus, a disc the size of a five-shilling piece would carry more current than one the size of a penny. The average disc used in commercial battery-chargers carries approximately $\frac{3}{4}$ of an ampere, and accepts an input voltage of approximately 4; so that if, for example, a direct current of 3 amperes at 100 volts is required, a construction or assembly is suggested, consisting of four paralleled units ($4 \times \frac{3}{4} = 3$), each unit comprising 25 discs in series ($25 \times 4 = 100$). In practice the design is not quite so simple, as safety-margins must be allowed, and as many as four simple paralleled paths are rarely used, it being preferred to use the bridge circuit and parallel the bridges.

However, it is easy to understand that in these rectifiers we have a very "elastic" medium, capable of being built up to any conceivable specification.

Copper-oxide rectifiers will not break or become damaged if dropped, are unaffected by vibration, and have no emission of any description to lose. They may be switched instantaneously on to full load without damage, are unaffected by accidental short-circuit, and may even be overloaded for a reasonable period before damage is likely to occur. Provided the temperature

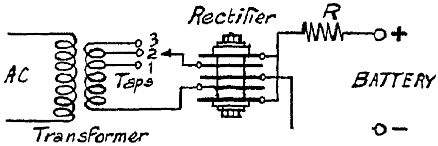


Fig. 14.—CIRCUIT OF COPPER-OXIDE RECTIFIER FOR BATTERY CHARGING

The transformer secondary winding is provided with tappings giving suitable voltages for adjustment according to the number of cells being charged. *R*, Ballast resistance.

could be kept down, there is theoretically no limit to the current which they may carry, whilst a voltage input excess of some 500 per cent. is necessary to puncture or break down the oxide.

Efficiency

As there are no moving parts to be driven, nor filament to heat, the efficiency is naturally highest of all rectifiers ; and this is still further enhanced by the fact that as they are to all intents and purposes permanent, and renewal costs do not arise, there can be no objection to utilising separate independent units for each charging circuit ; which does away immediately with practically all wasteful resistance control. The designer is, therefore, free to control the output mainly by a variation of input volts to the rectifier by means of tappings from the transformer secondary winding ; a method which economises current instead of wasting it. This, taken in conjunction with the other advantages enumerated above, results in an over-all efficiency in a copper-oxide rectifier charger of approximately 80 per cent. at the half-load, with which we are mainly concerned. Upon full load it is still better than any of those previously described, but the difference is not so great. Also, it maintains its advantage right down to practically no load ; the no-load losses being negligible.

Control

The control being effected by tapped transformer, and therefore dispensing with practically all resistance including the network, which in the case of the valve involves risk of one bank of cells discharging into another in the event of mains interruption, has the added advantage of entirely eliminating this possibility. The non-conducting properties of the rectifier in its reverse direction prevent discharge ; and as separate rectifiers feed each circuit, we have, in effect, a number of separate and independent chargers—each one for its own class of cell ; so that discharge from one bank to another is impossible, and any adjustment of control upon either circuit can have no effect upon the others.

The action of the copper-oxide rectifier is based upon neither chemical change, heating of fragile filaments, nor rotating machinery. Its efficiency at the order of loads we can expect under our own conditions is around the figure of 80 per cent., which is approximately one-fifth higher than the best of others, and it involves no repair or renewal costs.

The tapped transformer control (see Fig. 14) enables an immediate compensating adjustment to be made each time batteries are added to, or taken from the load.

The drawback of metal rectifiers with which we are concerned is the high initial cost. This is usually of the order of 10 per cent. to 15 per cent. above that of other systems. It may be as high as 20 per cent., but we should very carefully consider whether it is not better to pay this extra two or three pounds, for what, in effect, becomes the purchase of

an extra fifth of profit throughout the years following; and an uninterrupted trouble-free service.

SELENIUM RECTIFIERS

Another type of metal rectifier now being used for battery charging consists of aluminium or nickel-plated iron discs to which a layer of selenium is applied. Current will flow readily from the aluminium or iron to the selenium, but only with difficulty in the reverse direction. A number of elements are mounted on a spindle, together with connecting lugs and cooling fins when required, in the same general manner as the copper-oxide rectifier, but the pressure needed for contact is much less.

PREPARING BATTERIES FOR CHARGING

The procedure to be adopted in preparing the cells is the same, no matter what method of charging, as described later, is adopted. Beside the charger, one should have available a good hydrometer for measuring the specific gravity of the acid in the cells, a supply of commercial battery acid, a supply of distilled water, and an artificial load tester of good make.

Clean the Battery

The first procedure upon receiving a battery should be to thoroughly clean it. No good work was ever done with a battery whilst it was covered with corrosion and filth. A good plan is to wash this off in a large sink (rubber gloves are advised) with plain water. This will also remove the corrosion if any, which often collects upon the positive terminal. Next, thoroughly dry, and wipe off any grease which may be present, to prevent the collection of more dirt.

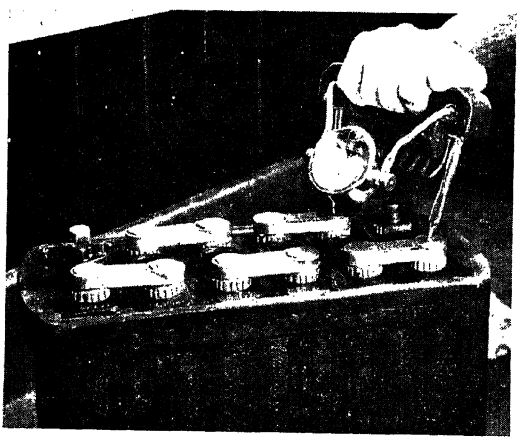


Fig. 15.—HIGH-RATE DISCHARGE TEST FOR TESTING BATTERY IN ORDER TO ASCERTAIN IF ANY OF THE CELLS ARE DAMAGED

Testing for Faulty Battery

We should next make use of the artificial load tester, upon each individual cell of the battery, in order to ascertain if any of the

cells are damaged. Instructions for the use of this piece of apparatus will be found enclosed with it upon purchase.

The habitual testing of all cells immediately upon coming into the station, preferably in the presence of the customer, is strongly recommended. It is useless to re-charge a cell which is not in a condition to retain its charge, as such procedure is not only waste of time and money; its early demise will reflect upon the efficiency of the charging station, even if the customer does not, in innocent ignorance, blame the station operatives for its damage. Immediate testing in his presence is a safeguard against either contingency. If any of the cells prove damaged, instructions for re-plating may be obtained at once, saving the customer's time, and incidentally increasing the turnover.

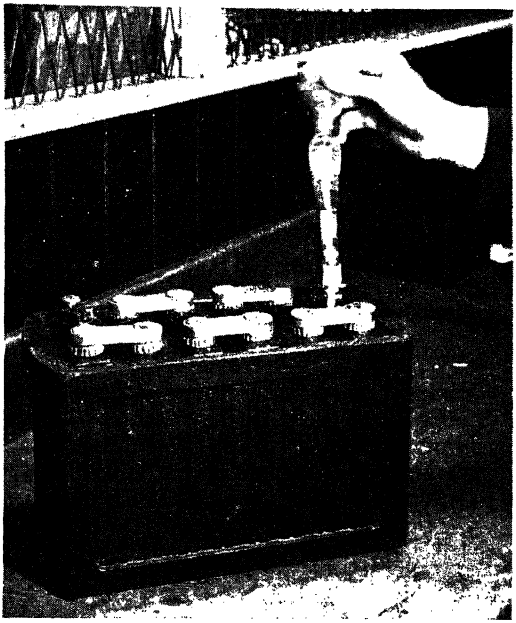


Fig. 16.—HYDROMETER TEST FOR SPECIFIC GRAVITY OF ACID

Too weak an acid will prevent full charge taking place.

Test for Specific Gravity

Assuming that the test shows no fault beyond discharge, we should next test the specific gravity of the acid. The correct figure for this varies somewhat with different makes, so that it would be wise to arm ourselves at the outset with a manufacturer's instruction booklet for all of the most widely used makes of battery. Battery makers will be found to be only too glad to assist in this direction when asked. The gravity of the acid in a cell which is fully discharged should be somewhere in the region of 1170, and if our hydrometer reads higher than the maker's specification with the battery in a discharged condition, we should remedy this by dilution with distilled water before placing on charge. Too strong an acid attacks the plates, whilst too weak an acid will prevent a full charge taking place.

The Charging Bench

Having dealt with these preliminaries, we may now approach the charging bench. This latter should be of rigid construction, preferably fitted with a thick covering of rubber or glass insulation which may be given an occasional wipe over, not only in the interests of cleanliness, but for prevention of leakage between cells and earth ; such leakages soon manifesting themselves if dirt be allowed to collect, owing to the fine spray of electrolyte which the cells throw out towards completion of charge. This very quickly forms a thin mud film comparatively highly conductive of current over the batteries and bench ; whereas, if cleanliness be strictly observed, no leakage is likely, as the electrolyte alone is of such high resistance as to be practically non-conductive.

TWO METHODS OF CHARGING

We now come to the actual charging plant and the method of charging. Although there seems to be an embarrassing range of plant available, there are only two methods of charging batteries, namely :

(1) The constant current or "series" method.

(2) The constant potential or "parallel" method.

We will deal first with constant current or "series" battery charging.

CHARGING BY THE "SERIES" OR CONSTANT-CURRENT METHOD

The following types of plant charge by the constant-current or "series" method when the mains supply is alternating current.

(1) Valve rectifiers,

(2) Metal rectifiers,

(3) Motor-generators.

The method of charging is the same in each case. The plant gives a certain current at a certain voltage. It has one or more charging circuits which give a variation of charging rates to enable you to charge different sizes of cells. In series charging the positive wire from the charging supply is connected to the positive terminal of the battery. Then the batteries are connected positive to negative until the required number are in series. Finally, the negative terminal of the battery is connected to the negative of the charging supply.

The number of cells you can charge depends upon the voltage of the plant you select. The charging circuit or circuits are fitted with resistances which enable you to adjust the charging rate so that you maintain a constant current through the batteries until they are fully charged.

Selecting Series Charging Plant

In selecting any type of plant which operates on the constant-current method, the first thing to do is to make certain that you have selected the most suitable voltage. This depends entirely upon the number of cells you require to charge at any one time. It is very easy to arrive at

the voltage required for any given number of cells. All you need do is to multiply the number of cells by 2·5. The voltage of any cell when fully charged is 2·5, and, consequently, if you have 20 cells to charge the voltage required is 50. Also, in the same way, if you select a 75-volt plant, you can connect—$\frac{75}{2\cdot5} = 30$ cells. If the plant is 30 volts, you can connect—$\frac{30}{2\cdot5} = 12$ cells.

In selecting the most suitable voltage the calculation should be taken on the basis of the maximum number of cells you require to charge at any one time. If, for example, you anticipate a weekly load of, say, 30 12-volt batteries and 10 6-volt batteries, it might be assumed that the average *maximum* number of cells you require to charge at any one time would be 5 12-volt batteries = 30 cells, plus 3 6-volt batteries = 9 cells, making a total of 39 cells.

Your most suitable voltage for this load, if you use only one circuit, would therefore be $2\cdot5 \times 39 = 97\cdot5$ volts, or, say, 100 volts.

Charging Different Sizes of Batteries at Different Charging Rates

This calculation is, however, based upon the use of only one charging circuit, which means you would have to charge all your batteries at the same rate. It is more convenient to have several circuits, so that you can charge different sizes of batteries at different charging rates. If, for example, you selected a plant with two charging circuits, then the voltage of each of these circuits need be only 50, which would give you the same capacity, or, in other words, enable you to charge the same total number of batteries at any one time.

Multiple Circuits

From a practical point of view care is necessary in selecting the number of circuits on the plant you install. Multiple circuits are very useful. They enable you to deal efficiently and easily with all types of batteries. You can, for example, have one circuit with a low current rate for radio batteries, of the mass-plate pattern. A suitable current rate for such batteries is about 1 amp. Another circuit at, say, 3 amps. enables you to deal with larger radio cells. A further circuit at, say, 6 amps. enables you to deal with the smaller range of car-starter batteries and a further circuit at, say, 8 amps. gives you full ample charging current for larger car-starter batteries.

In practice, the best thing to do is first of all to work out the average number of different sizes of cells you require to charge at any one time. Then multiply the number of cells which comprise the largest group or groups by 2·5. This gives you immediately a suitable voltage for your charging plant. That is, if you have, say, 20 mass-plate radio cells in one group, 30 multi-plate radio cells in another group, and the third group

comprising 5 12-volt car-starter batteries, you arrive at your voltages as follows :

Group 1.—20 2-volt cells = 50 volts.
Group 2.—30 2-volt cells = 75 volts.
Group 3.—5 12-volt batteries = 30 2-volt cells = 75 volts.

You would, therefore, in this case select a 75-volt plant.

Charging Rates

The question of charging rates is easy. You arrive at the average charging rate required for the various groups of batteries and select a plant which gives you circuits accordingly. Actually, you will find your needs met very excellently by the wide range of standard chargers which are available having carefully selected charging rates.

Connecting Up

We have to decide at what current to charge the battery, and here, at least until from experience we can tell by examination, we should consult the maker's instructions. If a 12-volt battery, it will be found most likely to be in the region of 8 amps.

Assume we have a charger with at least one 8-amp. circuit, capable of charging thirty-six cells simultaneously ; and that we have, ready for charging, three 12-volt and four 6-volt batteries. As there are six cells to each 12-volt battery and three cells to each 6-volt battery, the total number of cells is thirty. We are, therefore, well within the loading capacity, and may proceed to connect them to the charger, before switching on.

We take the first battery, and connect its positive terminal (marked by a cross or enamelled red) to the positive (similarly marked) terminal of the charger ; or to the circuit chosen, if a multi-circuit charger.

We then connect the negative of this first battery to the positive of the second, and the negative of the second to the positive of the third, and so on until we have only one battery terminal left. This will be a negative, and is then connected to the negative terminal of the charger, thus completing the circuit. Care must be taken to use stout, flexible connecting links capable of carrying the 8 amps. without heating, and to make good tight joints to prevent sparking. As the batteries give off highly inflammable gas towards the end of the charging period, the importance of this precaution cannot be overstressed. It is also a good plan to erect a " no smoking " notice in the charging room, and to strictly observe it ourselves. Ventilation should not be overlooked ; and is as important to safety as to health.

Switching on the Charger

Assuming we have now connected all in order, and ascertained the charging rate to be 8 amps., we should next see that the charger controls

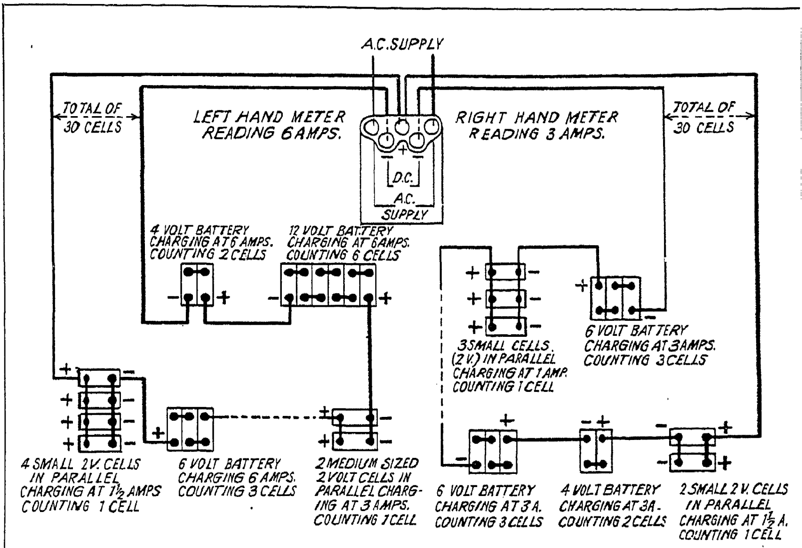


Fig. 17.—Two-circuit battery charger

Showing cell grouping to provide suitable charging rates for different sizes of batteries. Maximum voltage of charger, 75.

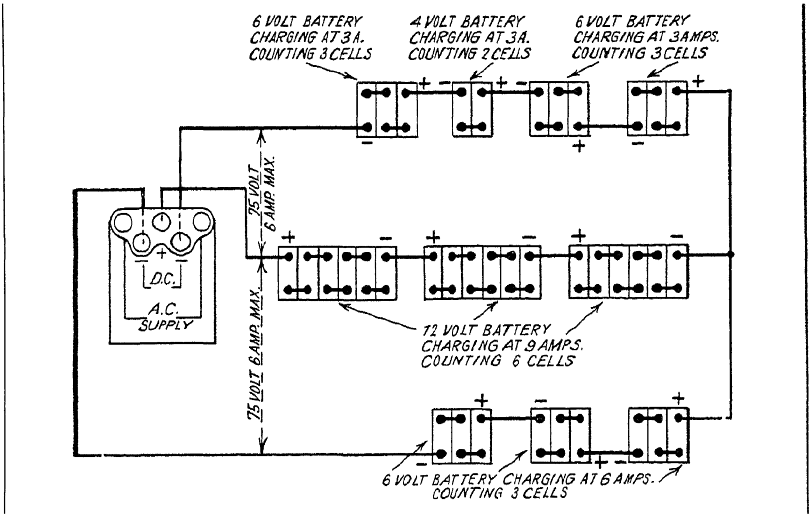


Fig. 18.—Two-circuit battery charger, showing an ingenious method of grouping cells of different charging rates

Meter readings as Fig. 17.

are in their minimum current positions; and then switch on. We shall probably see a small reading upon the appropriate meter, or none at all. In either case, we can next operate the current control, in accordance with the instructions issued with the charger, until we obtain the required 8-amp. reading. By making occasional adjustments just a few times during the period of charging, this current can be kept approximately constant until the cells are fully charged.

Calculating the Approximate Charging Time

We now wish to know for how long the batteries must be left on charge, and just how to ascertain when they are fully charged.

In order to save the time which would be expended in repeated tests throughout the period, we can approximately fix the charging time by calculation. The formula for this is: Ampere-hour capacity of the battery divided by the charging rate in amperes, equals the time in charging hours. Thus, if the ampere-hour capacity is 80 and the charging rate 8, the approximate charging time will be 10 hours. The ampere-hour capacity of the battery may be ascertained from the maker, if the information is not marked upon it.

How to Tell when Batteries are Fully Charged

It is advised, however, to use this formula only up to a point. To ascertain the precise condition of the cells, the hydrometer and the voltmeter should be put to use.

The voltage of each cell should be 2·5 to 2·7. The cells should be freely "gassing" or "bubbling," and the specific gravity of the acid should agree with the maker's instructions. ALWAYS SWITCH OFF THE CHARGER BEFORE DISCONNECTING ANY CELLS.

Series-parallel Method of Connection

All the preceding remarks have been based upon the batteries in the various charging circuits being connected in series, as indicated in Fig. 4. Sometimes it happens that we have a larger number of cells than can conveniently be connected in series. Supposing, for example, that the plant gives 75 volts. Dividing by 2·5, we see immediately that we can connect up to 30 cells in series. It might be that we have a plant with a capacity of 4 amps. on one charging circuit, and we might have, say, 60 cells which we would like to connect to this circuit and of which the charging rate is, say, 2 amps.

It is quite possible to do this by using what is called the series-parallel method of connection. This simply means that we make up two groups of cells in series, in our case with 30 cells in each group. We connect the positives of the two groups together and the negatives of the two groups together and then connect to the positive and negative terminals of the charger. Figs. 6B-C, 17 and 18 show various series-parallel arrangements.

It must be remembered that the total number of cells in each of the groups must be the same. Furthermore, the total current which you take from the charger will divide between the groups. In other words, if we connect the 30 cells mentioned above with a charging rate of 2 amps., we set the resistance on the switchboard to give 4 amps., and this will be divided approximately between the two groups and 2 amps. will flow in each group. We can have more than two groups, say three, four, or more, and the current will divide according to the number of groups we connect. The number of cells in each group, however, must, as previously mentioned, be the same.

We cannot control the charging rate of each group of batteries forming a series-parallel circuit. We have no resistance in the various groups to do this ; all we can do is to control the current flowing into the groups as a whole. Actually, the current which will flow in the various groups depends entirely upon the condition of the cells in these groups. This is a drawback in practice, because if the cells in one group are low they will take a heavier current than those in another group where the cells happen to be in good condition. One very suitable way of overcoming this difficulty is to use a separate sliding resistance with self-contained ammeter. This small portable resistance and ammeter can usefully be attached to any group of cells in a series-parallel circuit and individual adjustment of the charging rate conveniently made by adjusting the sliding resistance.

Care of the Battery

Before returning the battery to the customer, it should be wiped clean and dry, afterwards the terminals should be painted over with a liberal treatment of Vaseline and the residue carefully wiped away. This will prevent corrosion and ensure that when next the battery comes into the station for attention, it will be in a fit state to handle.

Do not leave a battery for long in a discharged condition. This causes the plates to sulphate. Do not use a battery whose voltage has fallen below 1·85 volts, or whose acid gravity is below the discharge figure of the maker, or expensive damage may result. Do not allow the acid level to fall below the top edges of the plates. If below this level, replenish with distilled water. Never use tap water; it contains impurities, and is usually somewhat alkaline in nature, thus lowering the gravity of the acid. Do not strengthen the acid just because it is weak. Find out, first, whether the battery is discharged, in which case the weakness is a normal condition and will strengthen itself during charging. Finally, never place a battery on charge the "wrong way round" or it will be ruined.

Provided the foregoing advice is observed, especially regarding cleanliness, there is no reason why the operation of the charging station should be anything but a profitable and interesting occupation.

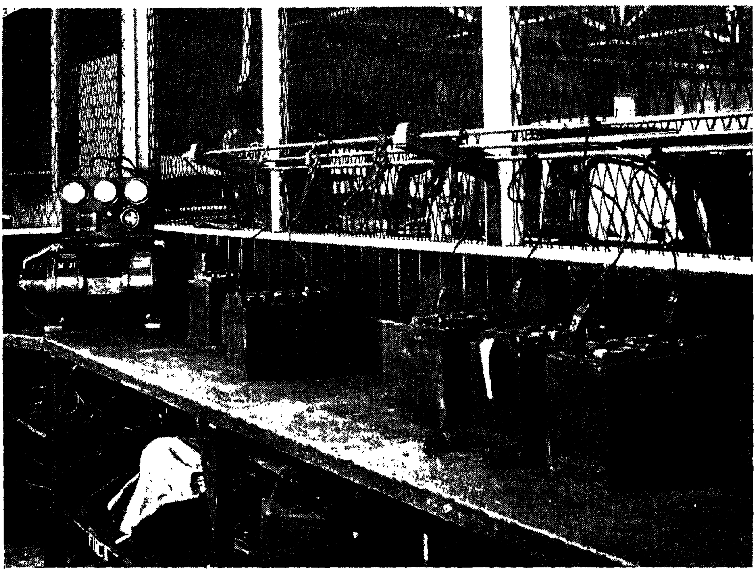


Fig. 19.—CONSTANT-POTENTIAL MOTOR-GENERATOR CHARGING PLANT

CHARGING BY THE CONSTANT-POTENTIAL METHOD

For constant-potential battery charging, a motor generator or commutating rectifier supplying a constant voltage is used. Instead of connecting a large group of batteries in series across the circuit, we take 6-volt or 12-volt car batteries, or groups of 3 or 6 radio cells, and connect them straightaway to long copper bars (busbars). These busbars are supplied with direct current from the motor generator or commutating rectifier, which gives a comparatively large current output and has a voltage that remains constant under all load conditions. There are both 2- and 3-busbar sets. The 2-busbar set has only one voltage, either $7\frac{1}{2}$ or 15 across the busbars. The 3-busbar set has two voltages, $7\frac{1}{2}$ across the centre and either of the outer busbars and 15 across the two outers. The voltage is controlled within limits by a resistance.

Connecting the Batteries for Charging

A 6-volt battery fully charged will read $7\frac{1}{2}$ volts, while a 12-volt battery will read 15 volts. Now, the voltage at the busbars should be set to $7\frac{1}{2}$ or 15, as the case may be. All you actually do is to make up your

cells in 6- and 12-volt units, of either three or six 2-volt cells in the case of radio batteries or 6- or 12-volt car-starter batteries, and connect these cells to the busbars by means of wires having quick-grip connectors. The positive of the battery goes to the positive busbar and negative of battery to negative busbar.

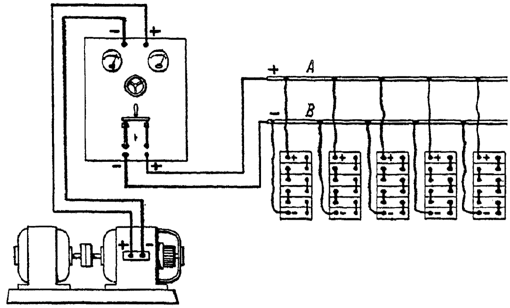


Fig. 20.—LAYOUT OF A CONSTANT-VOLTAGE MOTOR GENERATOR WITH SWITCHBOARD AND ITS TWO COPPER BUSBARS TO WHICH BATTERIES IN 12-VOLT UNITS ARE

Fig. 20 is a diagram of a constant-voltage generator with switchboard and two copper busbars to which batteries in 12-volt units are connected. The dynamo has a given output in ampères at a fixed constant voltage of 15, the regulation being constant between no-load and full load.

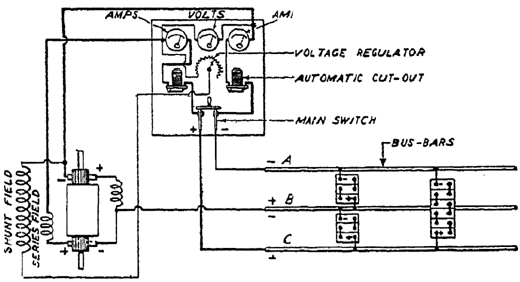


Fig. 21.—A CONSTANT-VOLTAGE CHARGING ARRANGEMENT PROVIDING A COMBINATION OF TWO VOLTAGES BY THE USE OF THREE BUSBARS

Three busbars give three separate charging circuits, two at 7½ volts and one at 15 volts.

A motor-generator with three busbars is illustrated in Fig. 21. The bars give three separate charging circuits, two at 7½ volts and one at 15 volts. Batteries, assembled in 6-volt units, are connected across either the positive busbar *C* and the positive and negative busbar *B* or, alternatively, between the positive and negative busbars *B* and the negative busbar *A*.

In both cases you connect your 6-volt batteries across the two points which give a voltage of 7½, and they are connected to positive and negative points in each case. Batteries in 12-volt units are connected across positive busbar *C* and negative busbar *A*, again across two points which are positive and negative respectively, but which, in this case, give 15 volts. The batteries connected to busbars *A* and *B* should be as nearly as possible the same as across busbars *B* and *C*. The two ammeters which indicate the charging current on each side of the system make it convenient to obtain the closest possible balance.

How the Battery is Charged

Assume that we have a constant-voltage plant giving 15 volts, let us see what happens if we connect a 12-volt battery to the 15 volts. The current that will flow through each cell is equal to—

$$\frac{\text{Voltage of circuit (15)} - \text{voltage of cell}}{\text{Resistance of cell}}$$

Assuming the voltage of each cell of the battery in its discharged condition to be 1·8, the total voltage of the 12-volt battery will be $6 \times 1{\cdot}8 = 10{\cdot}8$.

Assuming the resistance of each cell to be 0·025 ohm, the total resistance will be $6 \times 0{\cdot}025 = 0{\cdot}15$ ohm.

The current flowing at the start will be—

$$15 - 10{\cdot}8 \qquad 4{\cdot}2 \qquad 28 \text{ amps}$$

At first sight it may seem wrong for a battery with a nominal charging rate of, say, 8 amps. to be connected to a circuit from which it takes 28 or more amps. It is possible, however, to send almost any current into a battery when it is first connected so long as the temperature does not rise above 100° F. This charging rate does not last long, for immediately the terminal voltage of the battery begins to rise as the battery becomes charged the charging current decreases automatically.

After a short time, say half an hour, the voltage of each cell becomes, say, 2·1, making a total of 12·6 volts. If the 15 volts is kept constant, the current will be—

$$15 - 12{\cdot}6 \qquad 2{\cdot}4 \qquad 1$$

After, say, 1 hour, the voltage of the cells will be, say, 2·2. The current will then be—

$$\frac{15 - 13{\cdot}2}{0{\cdot}15} = \frac{1{\cdot}8}{0{\cdot}15} = 12 \text{ amps.}$$

After, say, 4 hours, the voltage of the cells will be, say, 2·4. The current will then be—

$$\frac{15 - 14{\cdot}4}{0{\cdot}15} = \frac{0{\cdot}6}{0{\cdot}15} = 4 \text{ amps.}$$

At the end of the charge the voltage of the 12-volt battery will be 15. This is equal to the voltage of the plant, also 15 volts, and consequently no current will flow. Actually, in practice, a very small current flows in this condition.

A Typical Constant-potential Set

The actual arrangement of a constant potential charger will be made a little more clear by a study of the illustration in Fig. 19.

This shows an actual constant-potential set installed. The arrange-

ment is similar to a motor-generator. You have a motor operating from the supply which drives a D.C. generator. The generator has two commutators, each commutator gives 7½ volts, and the two are joined in series exactly as in Fig. 21, giving the two separate 7½ and 15 volts which are applied to the busbars.

The switchboard which controls the plant is fitted with two ammeters and a voltmeter which measures the total voltage of 15. The ammeters register the current taken by each half of the busbars, i.e. each 7½-volt section. It will be noted in Fig. 21 that two automatic cut-outs are fitted. The function of these cut-outs is merely to disconnect the batteries from the machine should the plant shut down through failure of the supply. Figs. 8 and 8A illustrate examples of constant-potential sets, incorporating commutating rectifiers.

The arrangement of the busbars will be clear from the illustrations, and it will be seen that they are mounted over the charging bench and the batteries are connected to the busbars by ordinary charging leads.

In practice constant-potential sets, such as are illustrated, are supplied absolutely complete, including the motor and constant-potential dynamo on bedplate, switchboard, busbars, insulators which hold the busbars, and all the actual charging leads required.

Charging Discharged Battery in Eight Hours

By this method of charging it is possible to charge fully a healthy discharged battery in eight hours. If, however, you were to connect a battery to your C.P. set and there happened to be one cell short-circuited, then, supposing the battery was a 12-volt, its maximum voltage would be only 10 or 12·5 fully charged.

In these circumstances the C.P. set would continue to pump a heavy charge into the battery when the good cells were fully charged, owing to the difference in voltage between the busbars and the battery terminals, namely, 12½ volts against 15 volts. Under these conditions the battery would severely overheat, and damage might also result to the good cells.

Batteries that are Badly Run Down

Similarly, with a battery which is badly run down or which is unhealthy the back-E.M.F. when it is first connected will be considerably lower than normal. The difference in voltage will, therefore, be high and the charging current will be high in proportion. This high current would result in an excessively high battery temperature and would harm the battery. We can always reduce the charging current flowing through a battery by reducing the voltage applied to it. If, therefore, we reduce the 15 volts for any particular unhealthy battery or batteries, we automatically reduce the current.

This is done in practice in a very simple manner by providing special

leads by which the batteries are connected to the plant, these leads incorporating a sufficient amount of resistance to reduce the initial current to a suitable value, which in practice is 10 or 20 amps., depending upon the actual battery.

Charging New Batteries

Always charge new batteries by the series method. If you have a "series" charger, connect them to the plant in the ordinary way and keep the charging current at the rate given on the battery labels "for first charging." You can charge a new battery by the series method with a constant-potential plant while other batteries are still being charged by the constant-potential method. This is provided for by the variable-resistance leads, which enable you to put any required current into a battery for any length of time, and an ammeter should be provided with the plant to enable you to read the current going into a battery. Always follow the maker's instructions very carefully when giving a battery its first charge.

Repaired batteries need the same treatment as new batteries if the negative plates have been discharged by letting them stand in air. On completing the charge of repaired batteries particular attention must be paid to the electrolyte, as this is apt to vary considerably at the conclusion of the charge when the old negatives are replaced.

HOBSON TELEGAGES

NOTES ON OPERATION AND SERVICING

OBSON telegages are employed for indicating the petrol level in the fuel tank, the engine oil pressure, and the cooling-water temperature on dashboard instruments. Electric-type telegages are used for all these purposes, while pressure-type telegages are used for fuel-tank level indication.

ELECTRIC FUEL-LEVEL TELEGAGE

The Hobson electric K-S fuel-level telegage system consists of three parts—the tank unit (which is called "the sender"), the instrument unit (called "the receiver"), and the single wire connecting them.

The Controlling Element

The controlling element of both the sender and the receiver is a bi-metal strip, the bending of which, when heated, is utilised for operating the gauge.

The bi-metal strips in both the sender and receiver are similar—that

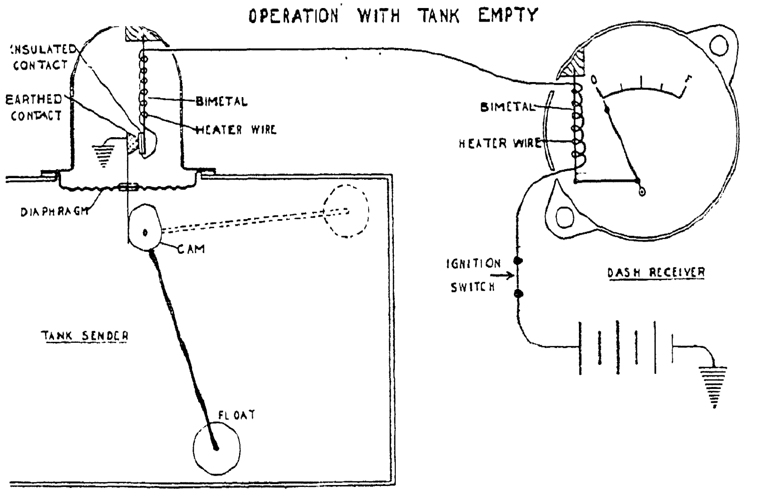


Fig. 1.—THE POSITION OF ALL PARTS OF ELECTRIC FUEL-GAUGE SYSTEM WHEN TANK IS EMPTY

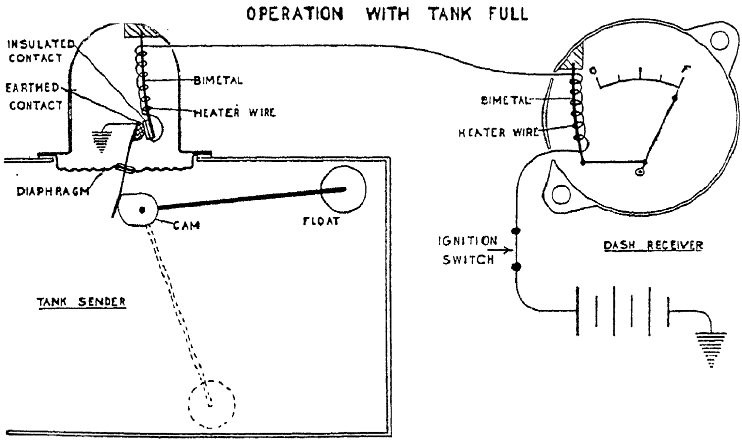


Fig. 2.—Position of all parts of electric fuel-gauge system when tank is full

is, each will bend the same amount when heated to the same temperature. In order to heat both to the same temperature, each has an electrical heating unit wound around it. As will be seen in the diagram, these heating units are connected in series and the current flows from the battery through the receiver, then through the sender to the earthed contact, and the circuit is completed through the car frame back to the battery. The same current which passes through the receiver must also pass through the sender, so that both bi-metals will be heated the same.

The bi-metal in the receiver is anchored at the top, and the bottom is connected by a link to a pointer. Heating the bi-metal will cause it to bend to the right, and this movement, amplified by the linkage, will be transmitted to the pointer, moving it to the right.

The bi-metal in the sender is also anchored at the top, and carries a contact point at the bottom. When this bi-metal is heated, it moves to the right, away from the earthed point, and breaks the circuit.

How the Telegage Works—Tank Empty

Fig. 1 shows the position of all parts of a fuel-gauge system when the tank is empty. When the current is turned on, it will heat both bi-metals just sufficiently for the contact point of the sender to move away from the earthed contact. The actual movement necessary to break the circuit in the sender is so small that the movement of the pointer is not noticeable. As soon as the circuit is broken, the bi-metals begin to cool and straighten so that the contact is again made. This process of making and breaking contact continues from 60 to 100 times a minute, the bi-metal being alternately heated and cooled, but to the eye, the pointer on the dial is steady.

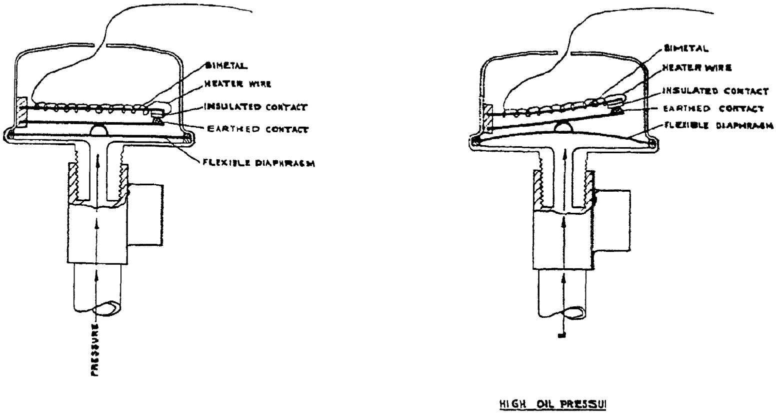


Fig. 3.—SENDER UNIT OF AN ELECTRIC OIL PRESSURE TELEGAGE

Tank Full

Fig. 2 shows the position of the parts when the fuel tank is full. The float has moved upwards and, through the action of a cam, has pushed the bottom of the rod, on which the point is mounted, to the left, and the point has moved to the right, this movement being made possible by mounting the rod on a flexible diaphragm. With the earthed point moved to the right, it will require more heat to bend the bi-metal in the sender enough to move the contact point away from the earthed point and break the circuit. The same current, however, that heats the sender bi-metal is also heating the receiver bi-metal and it likewise bends more, moving the pointer to the right. As soon as a sufficiently high temperature is reached, the points open and close alternately, maintaining this temperature and keeping the pointer steady at "full" on the dial.

With the float in any intermediate position, the earthed point would assume a similar intermediate position, and the temperature of the bi-metals at which the contact was broken would determine the position of the pointer on the dial.

Since this gauge depends entirely on temperature for its operation, a change in voltage in the system does not affect the gauge reading. A higher voltage will show a change in fuel level faster, but the final reading will be the same. The pointer is not affected by jolting of the car, since it is constantly held in position by the bi-metal.

Since it takes approximately 15 seconds for the gauge pointer to change from "Empty" to "Full," bobbing of the float is not registered. The actual reading in case of a bobbing float is the average level of the float, which is the actual level of the fuel in the tank when at rest.

The only parts susceptible to deterioration in the entire system are the

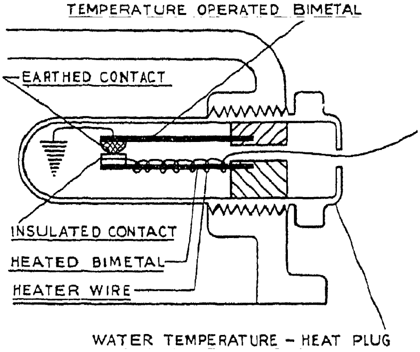


Fig. 4.—SENDER UNIT OF ELECTRIC WATER-TEMPERATURE TELEGAGE

contact points. Since the maximum current flowing while the points are in contact is only three-tenths of an ampere, the life of the points is of little concern.

ELECTRIC OIL-PRESSURE TELEGAGE

The method of operation of this device is almost identical with that of the fuel-level instrument, except that the sender instrument has its diaphragm subjected to the engine-oil pressure. The diaphragm is deflected more or less, depending upon the oil pressure, and this in turn, by varying the degree of which the bi-metal strip is bent, gives a correct reading on the receiving instrument. Fig. 3 shows the sender unit.

ELECTRIC WATER-TEMPERATURE TELEGAGE

With these devices the sender instrument consists of a watertight plug which is fixed in some convenient place in the outlet of the cooling system, and which inside it contains the bi-metal strip. This deflects to a degree depending upon the temperature of the surrounding water, and the receiving unit records in the same fashion as the preceding two, except that its dial is marked off in degrees of temperature. This instrument will stand a temperature of 275° F. without damage, and possesses all the advantages of the preceding instruments in the way of ease of assembly and silence. Fig. 4 shows the sender unit.

SERVICE INSTRUCTIONS FOR HOBSON ELECTRIC TELEGAGES

The instructions below apply to all three types of electric gauges. To simplify matters, the instrument panel units are referred to as "receivers," and the petrol tank unit, oil unit, and radiator unit, as "senders."

Receivers of one type are not interchangeable with those of another type. This also applies to the senders. A receiver of one type can be used for checking another receiver, however, and the same applies to senders.

Necessary Equipment for checking an Installation

(1) One extra receiver (preferably petrol).

(2) One extra sender (preferably petrol).

(3) Two 4-ft. lengths of insulated wire equipped with clip terminals at each end.

Do not replace any unit until standard tests have been made which

definitely prove it to be defective or damaged. Handle all units carefully.

Never subject a gauge unit alone to the full 6-volt current beyond three-quarters of its scale reading, as this will burn out the heater coil.

To check Sender

(1) Disconnect wire at sender and connect it to extra sender. Earth extra sender to car frame and turn on ignition switch.

(2) Move float of extra sender from empty to full position and watch action of the receiver while doing this. (Allow 10 to 15 seconds for receivers to read full scale.)

(3) If receiver registers correctly with extra sender, then—

(*a*) Original sender is improperly earthed (because of paint or grease), and this must be corrected, or—

(*b*) If car is radio-equipped, the condenser attached to sender may be "shorted." This would cause over-reading whenever ignition switch was on. Condenser can be checked by disconnecting wire leading from it to sender. If gauge operates correctly with condenser disconnected, then replace condenser.

Use only Dubilier condensers No. 43–5 type "A" of ·05 microfarad capacity. Any other may damage the gauge system.

(*c*) Original sender is damaged or defective, and must be replaced.

(4) If receiver performs the same with extra sender as it did with the original sender, then check wiring.

To check Wiring

(1) If wire connecting sender to receiver is broken or earthed, repair or replace.

(2) If both wiring and sender check correct, then check the receiver.

To check Receiver

(1) Disconnect wires from receiver and attach to extra receiver. Turn on ignition switch.

(2) If extra receiver reads correctly, then replace receiver.

(3) If extra receiver reads the same amount as original receiver, then—

(*a*) Previous checks were not properly made, or—

(*b*) Installation was correct to begin with.

All gauges are 6-volt, so the resistance fitted at side of receiver when circuit is 12-volt should on no account be removed.

Routine for checking Oil Pressure Telegage

When checking the oil pressure telegage, the following routine may be used :—

(1) Short the engine unit (sender) by earthing the wire leading to it.

(2) Turn on the ignition switch, and if the receiver now registers, then it and the wiring are correct, and the sender is the cause of the trouble. Replace with a new unit. (This test should be only a momentary

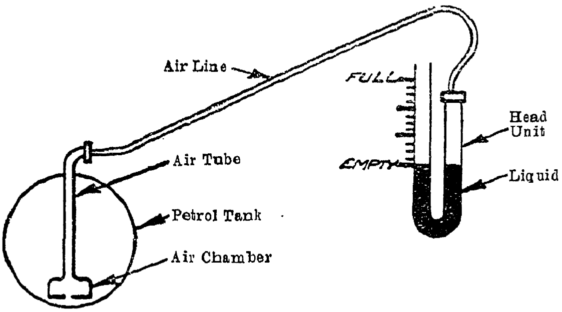


Fig. 5.—SIMPLE TELEGAGE IN OPERATION—TANK EMPTY

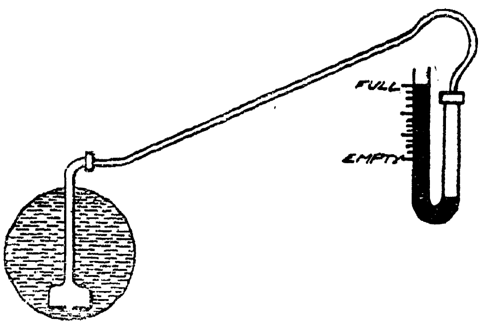


Fig. 6.—SIMPLE TELEGAGE IN OPERATION—TANK FULL

one, as the full 6 volts of the electric system are imposed on the instrument, and it will burn out if tested like this for any period.)

(3) If the receiver fails to register with the sender shorted and the ignition switch on, then the wiring and connections should be carefully checked. If no fault can be found with these, replace the receiver unit and check once more.

HOBSON K-S PETROL TELEGAGE (PRESSURE TYPE)

The Hobson K-S petrol telegage (pressure type) consists of three units—the head, tank unit, and air line. In operation the air tube and air chamber of the tank unit, and the air line connecting the tank unit to the head, are filled with air (Fig. 5).

Operation

When the tank is filled the petrol tries to rise to the same level in the tank unit as it is in the tank, but cannot because of the air trapped between the bottom of the tank unit and the liquid in the head. The petrol trying to get into the air chamber presses on the trapped air and this pressure is transmuted through the air tube and air line to the head on the instrument board, where it is recorded by the rise of the red liquid in the glass tube (Fig. 6).

It can be seen from Fig. 6 that the operation of the telegage depends upon air being trapped securely in the tank unit and air line. A loose connection would permit the trapped air to escape, and the petrol would rise in the tank unit to the same level as in the tank. There would also be no pressure on the liquid in the head unit and the liquid would fall to the bottom mark on the dial regardless of how much petrol there was in

the tank. The connection can be tightened, but the head unit will not register correctly until the tank unit has been cleared of petrol and again filled with air. This is done by the surge of petrol as explained below in the description of the tank unit.

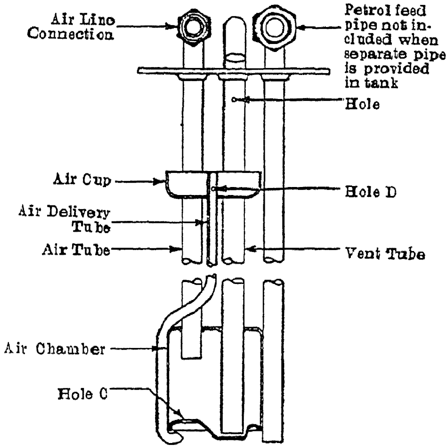


Fig. 7.—THE TANK UNIT

The Tank Unit

The tank unit (Fig. 7) shows the air tube and air chamber which must always be filled with air. The petrol tries to enter through hole *C* and thus presses on the trapped air. This is the only part of the tank unit that has anything to do with the reading of the gauge.

The vent tube, open at the top, is a safety device which protects the gauge against high pressure. It does not enter into the operation of the gauge in any way.

The remainder of the tank unit, that is, the air cup and air delivery tube, act only as a means of supplying air to the air chamber. This is to overcome the loss of air due to absorption in the petrol and contraction due to a sudden drop of temperature.

The air supply mentioned above is obtained by using the movement of petrol in the tank. When the air cup is above the level of the petrol it is constantly being filled by the surge and splash when the car is in motion. This petrol runs through the drain hole *D* and down the air delivery tube, drawing with it a few bubbles of air. At the bottom of the tube the air bubbles out and rises under the air chamber. It enters the air chamber through hole *C*, and displaces any petrol which may be there. When the air chamber is full of air these bubbles simply pass off and are not used.

The Head

The head, shown in Fig. 8, is mounted on the instrument board. It is simply a U-tube containing a special heavy, red liquid. (Hobson's K-S liquid is used because of its specific gravity and other characteristics. *No other will do.*) The front half of the U-tube is a glass tube open at the top. The back half is a brass tube. The calibrating wires are essential for accurate operation. They compensate differences in glass tube diameters, and the correct amount is inserted in each head at the time of manufacture. They should therefore not be interfered with.

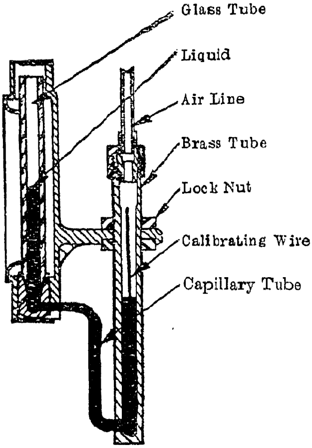


Fig. 8.—THE HEAD

The Air Line

The air line is simply a hollow tube which connects the tank unit with the head. Any pressure which comes through the air line will press the liquid downward in the brass tube and upward in the glass tube. In fact, the difference in levels of the liquid in the two tubes is an exact measurement of the pressure coming through the air line, and hence records the depth of petrol in the tank. By marking the dial in gallons an exact reading in gallons is shown on the instrument board.

To have the gauge read correctly, three things are necessary :

(1) The red liquid in the head must be set at the bottom line of the dial when the air line is disconnected, and hold the setting. If the head shows a leak and will not hold setting, it should be replaced.

(2) The air system must be free from leaks or obstructions. The most common obstruction is petrol which, however, *can only be driven into the line when there is a leak or connections are not properly made.* Petrol, being a moving obstruction, will cause a very erratic reading of the

(3) The tank unit must supply air by the surging of the petrol, as described above. When you have these conditions and the gauge is reconnected the liquid in the head will rise when the car is being driven and will continue to rise until it records the true contents of the tank. Stopping, starting, and turning of corners will hasten this action. After this the gauge will not again lose its reading unless disconnected.

SERVICING PRESSURE-TYPE TELEGAGE

Servicing a telegage is easy provided the following instructions are closely followed. The use of any other method will produce no results.

The gauge head must not be removed from the instrument board, and no unit must be changed until you have followed all instructions.

Make these Checks First

(1) *Remove Tank-filler Cap.* On cars where a vent-hole in filler cap is necessary, see that it is free from dirt and open. Do not replace filler cap, or drain petrol tank.

(2) *Try Tank Unit Connection to be Sure it is Tight.* Use a second spanner to prevent tube from twisting.

(3) *Disconnect Gauge Line (Air Line) at Front End Only.*

Red Liquid must now read even with Bottom Line of Dial. Add or remove liquid as required at top of brass tube where air line was disconnected. Use a medicine dropper to add liquid; use a match to absorb some. Be careful that match does not pull out any shims (small wires). *Never* loosen locknuts to move brass tube up or down.

If dial or paper-reflector back of glass tube is stained at the bottom, install a new complete gauge head.

Use only Hobson K-S Telegage Liquid—no other will do.

(4) *Dry Air Line.* Follow exactly or no results will be obtained.

(*a*) Use a good motor hand tyre pump. (Never use compressed air.)

(*b*) Remove metal tip from tyre pump hose.

(*c*) Push hose securely over front end of line.

(*d*) Give at least fifty full continuous strokes.

(5) *Reconnect Air Line, making Tight Joint.*

(6) *Replace Tank-filler Cap.*

You are now ready to make a test to see if the trouble has been corrected.

Test

Determine whether you can bring gauge up to proper reading by supplying air to the tank unit.

If the petrol-feed pipe is in tank unit, disconnect the petrol-feed line from the top of the vacuum tank or petrol pump, and blow with the mouth through this line into the petrol tank.

If the petrol-feed pipe is not in tank unit, drive the car until the red liquid no longer rises. A correction cannot be made if the tank is more than three-fourths full.

If the reading now stays set with the car stationary, then the telegage is correct and the job is completed.

If, however, you cannot get a reading by driving or blowing back through the petrol-feed line, or you can get a reading, but it will not hold for an hour with the car stationary, then there is a defective unit to be located by following the repair instructions below.

Repair Instructions

To determine whether the failure is in the air line or tank unit.

(1) Disconnect the air line front and rear.

(2) Inspect cones and seats for dirt or flaws.

(3) Blow out air line (see Check 4 above), and test for a leak. Place finger over one end and suck on the other end. If the suction created will hold the tongue *for one minute* the line is sound.

(4) If the air line shows a leak, or is blocked, it must be changed.

(5) If the air line and connections prove correct, the defect is in the tank unit, which must be changed.

Caution

Defective tank units are very rare ; therefore, inspect carefully the gauge head, air line, and connections, as the trouble is more likely to be in one of these units than in the tank unit.

It is frequently thought that the calibrating wires are for the purpose of regulating the height of the liquid when replenishing. This is incorrect. They are solely for the purpose of calibrating the unit when manufactured, as stated above. They must neither be removed nor added to on any account. When the unit is overhauled for any purpose, these wires should be cleaned from any corrosion so that their correct value is restored.

Other types of electrically-operated petrol-level and oil-pressure gauges are dealt with in another section of this volume.

FUEL PUMPS

By JOHN L. P. PINKNEY, M.S.A.E.E.

IN the days when petrol tanks were fitted behind the dashboard and at a height above the carburettor, it was a simple matter for the carburettor to be kept continuously supplied with fuel by means of gravity feed. This position of the petrol tank was dangerous for the passengers in the event of an accident causing a fire, and it also interfered with the designers' progressive attempts to smooth out the lines of the bodywork. The ultimate position of the tank was either at the rear of the car or under one of the seats, but these positions were at a lower level than that of the carburettor, so that gravity feed was out of the question. This new position, then, necessitated some form of forced feed or else a method whereby the petrol can be lifted up to a level above that of the carburettor. Various methods have been adopted to achieve this, and one of the better known was by means of the Autovac.

THE AUTOVAC

This method makes use of a small tank fitted underneath the bonnet but above the level of the carburettor. The top of this tank is connected to the main petrol tank by a copper pipeline. The bottom of the Autovac is connected to the carburettor in the same way, so that if this tank is kept supplied with petrol from the main tank, the carburettor will be fed by gravity. But since the Autovac is above the level of the main tank, some means must be applied to force the petrol from the main tank to the Autovac. This is achieved by applying a suction to the Autovac by connecting the top of this to the induction side of the engine.

How it Works

By referring to the layout of the Autovac, it will be seen that the tank consists of two containers, an inner or vacuum chamber and an outer or gravity feed chamber. Inside the inner chamber is a float, which is connected by a rod to a fulcrum arm which operates the air valve and the suction valve. At the bottom of the inner chamber is a petrol-release valve. With the engine running, a vacuum is applied to the inner chamber which causes petrol to be drawn from the main tank. As the inner chamber becomes filled with petrol, the float rises, causing the fulcrum at the top to close the suction valve and to open the air valve. The collapse of the vacuum allows the weight of the petrol to

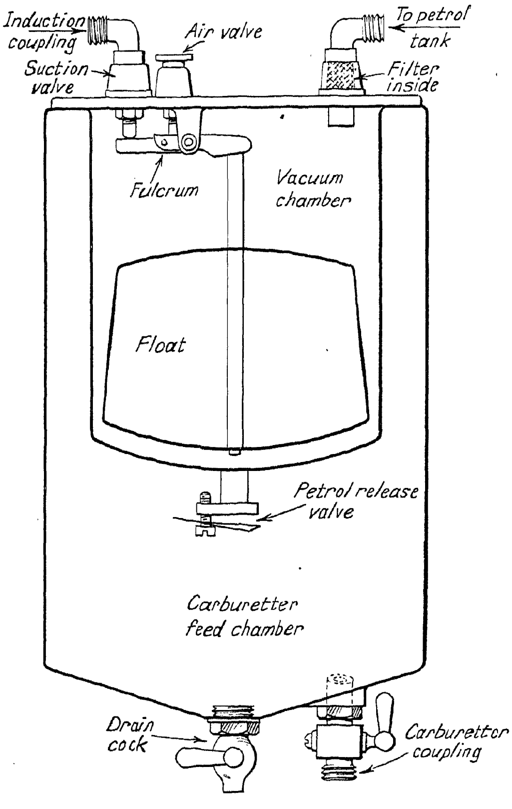


Fig. 1.—THE AUTOVAC, SHOWING INTERNAL ARRANGEMENT

force open the petrol-release valve at the bottom, the petrol then flowing into the outer chamber and thence by gravity feed to the carburettor. With the emptying of the inner chamber, the float drops, the vacuum valve opens, and the air valve closes, thus allowing the above cycle of events to be repeated.

Maintenance

This fuel pump is very reliable and needs very little attention, but the following points should be observed. All pipeline connections must be kept tight, as the smallest leakage will prevent a vacuum being formed. This also applies to the top plate of the Autovac, and if this is removed at any time it is important not to damage the cork packing and to see that no dirt is between the packing surfaces when reassembling. It must also be replaced in the same position, otherwise the air transfer hole will be blocked, resulting in a mysterious failure.

Cleaning Required

The petrol strainer situated on the top of the Autovac in the main supply coupling should occasionally be removed and washed in clean petrol, and the gauze dabbed with a stiff brush to remove dirt. See that the air vent in the main tank is open, otherwise the suction may cause the collapsing of the tank. Occasionally clean the faces of the valves, since any fluff or dirt on them will prevent the pump from working.

MECHANICAL PUMP

A very popular type of pump is the pressure pump which is mechanically operated by the engine. The engine must be specially designed to take the pump, since this is operated by means of a cam on the engine camshaft. Projecting out of the side of the pump is a lever which rests on the cam, so that the eccentricity of the cam forces the lever up and down. This movement transfers the pumping motion to a diaphragm made of petrol-resisting material to maintain a pressure of approximately 2 lb. per square inch. Above the diaphragm is a fuel chamber having a suction valve and a delivery valve. When the engine cam operates the pump lever, the diaphragm is forced downwards and produces a vacuum or suction action in the fuel chamber.

What the Vacuum Does

This vacuum draws the delivery-valve disc on to its seating, and at the same time the suction-valve disc is drawn off its seating. The vacuum is then displaced by petrol drawn in past the open suction valve. On the return stroke the diaphragm is forced upwards, and the pressure on the petrol in the petrol chamber forces the suction-valve disc on to its seating whilst the delivery valve disc is forced off its seating, allowing the petrol to pass out on its way to the carburettor.

Precaution to be Taken

With one type of this pump it is possible to fit the pump on the engine with the lever under the cam instead of at the top. With the pump in this position, the engine will not start, but the lever is liable to be broken, so care is required to see that the lever is in its correct position in relation to the cam before attempting to start the engine.

Testing the Pump

To test this type of pump, a fuel-pump test stand is available, which comprises a cast-iron upright stand with a pressure gauge reading up to either 8 or 10 lb. per square inch; two short lengths of rubber hose, complete with couplings; a glass sight gauge; a stopcock and two lengths of copper pipe. The stand is fixed to the bench, and directly underneath it is placed a liquid container, such as a 2-gal. petrol can with the top removed. One length of the copper pipe is connected to the left-hand coupling on the stand, and the other end of the pipe is located almost at the bottom of the petrol can. The other length of the copper pipe is connected to the right-hand coupling of the stand, and the other end of this pipe also leads down to the petrol can, but need not reach the bottom since it is only the return pipe (see Fig. 2).

Don't use Petrol

The can under the bench is filled with paraffin, since petrol is too dangerous to have about in open containers. The pump to be tested is

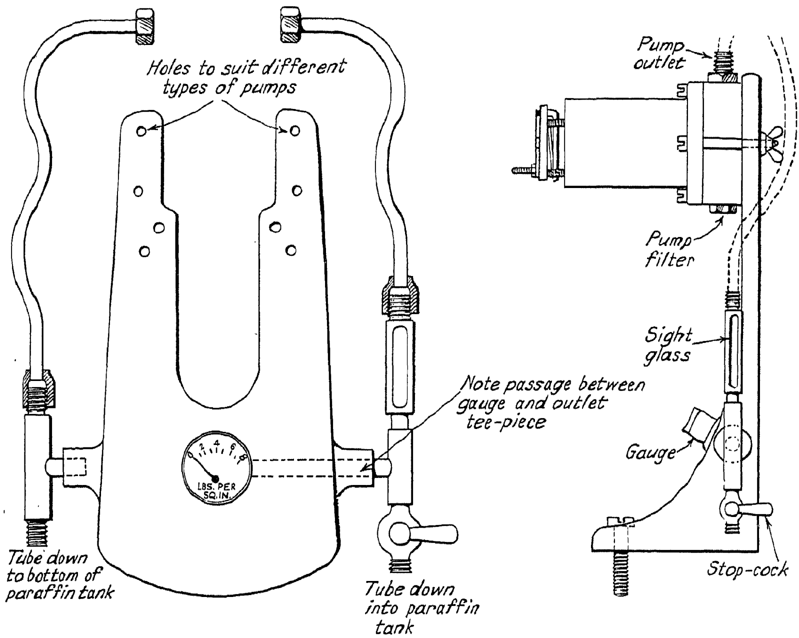


Fig. 2.—TEST STAND FOR BOTH ELECTRICALLY AND MECHANICALLY OPERATED PUMPS

fitted on the stand by means of the wingnuts provided, selecting the fixing holes in the stand to suit the holes in the flange of the pump.

Connecting the Pump

The outlet side of the pump is connected to the right-hand coupling of the stand by means of the short length of rubber hose. This side leads to the glass sight gauge. The inlet side of the pump is connected to the coupling on the left of the stand. It is essential that all of these connections are made airtight, otherwise misleading results will be obtained and the pump may not work.

Testing the Pump

To test the pump, the operating lever is given three or four strokes, when the pump should prime. The pump should be self-priming, and should not need priming from an outside source. Another ten or twelve strokes of the lever should cause the pump to deliver fuel. This can be checked by looking through the sight glass. After this test, a pressure test is next given.

Test for Pressure

The cock below the sight glass is closed and the operating lever depressed until a pressure of from 4 to 6 lb. per square inch is indicated on the gauge. The pump should be capable of holding this pressure for several minutes without much fall of pressure.

Another method of testing is by means of the A.C. Test Gauge, full particulars of which are given elsewhere.

If Pressure Falls

A rapid fall of pressure indicates an air leak or faulty valves, and to locate the source all connections should be tried for tightness. After testing, the inlet coupling is removed and the pump is tilted so that the paraffin in the pump will drain out ; a few strokes of the pump lever will soon empty out all the paraffin.

This type of pump can be fitted below the carburettor, thus permitting down-draught carburettors, which are fitted high up.

ELECTRIC PRESSURE PUMPS

The S.U. Petrolift

The trend of present-day progress seems to point to having everything on the car electrically controlled. This relates to petrol pumps, which are operated solely by the current from the battery and they are wound to operate from either 6- or 12-volt circuits. One of the best known of these pumps is the S.U. Petrolift. Its action is a reciprocating motion of a plunger in the centre of a solenoid coil. This coil is connected across the car battery, and the circuit is completed by way of two contacts which are magnetically operated by two permanent magnets (see Fig. 3).

Action of the Pump

The working of the pump is as follows : The plunger is of brass, with an iron ferrule at its upper end. The rocking make-and-break action of the two contacts is operated by means of two U-shaped permanent magnets. One of the magnets is close to the top of the contact rocker, and the other magnet is near to the bottom of the rocker. When the plunger is at the bottom, the iron ferrule is across the two poles of the lower magnet, thus causing the top magnet to draw the top of the rocker towards it. This brings the two contacts together and the circuit through the solenoid coil is completed. The energising of the coil draws the plunger up the barrel, and the position of the iron ferrule is changed from the lower magnet to the top magnet. This will also change the pull on the contact rocker from the top to the bottom and the contacts will be opened. When the contacts open, the circuit through the solenoid coil will be broken and the plunger will drop. But as soon as this occurs, the top magnet becomes free and draws the two contacts together again, and the above action is repeated.

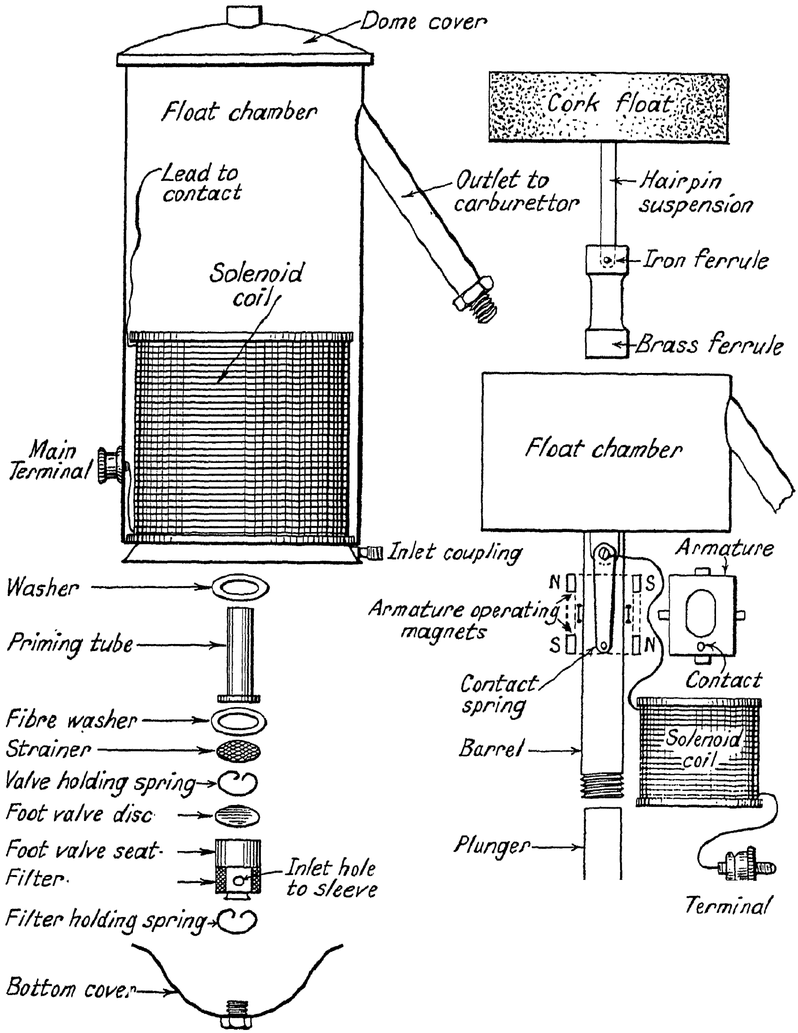


Fig. 3.—THE S.U. PETROLIFT

Showing internal construction with the parts in their order of assembly. The action of the pump is by means of the to and fro motion of the plunger in the centre of the solenoid coil. The coil is connected across the car battery and the circuit is completed by way of two contacts which are magnetically operated by two permanent magnets.

How the Petrol is Controlled

The reciprocating motion thus set up causes the petrol to be sucked up through two valves into the hollow stem on its way to the float chamber at the top of the pump. From here it is gravity fed to the carburettor. When the float chamber fills up faster than the carburettor can deal with, the pumping action is automatically stopped. This is brought about by means of a hairpin loop fastened to the cork float. When the float is at the top—that is, when the chamber is full of petrol—the hairpin loop holds up the plunger, and the iron ferrule continues to short out the poles of the top permanent magnet, thus causing the contacts to remain open until such time as the petrol is used up and the float drops.

To Stop Sparking at Contacts

To suppress the sparking at the contacts at break, a non-inductive resistance is placed across the winding and contacts to absorb the inductive voltage.

Servicing of Pump

There is very little to go wrong in the working of the pump, and the only trouble likely to occur is the sluggish action of the plunger through sticking, and the choking up of the filter which is situated at the bottom of the pump. After servicing the pump, it will be necessary to prime it by pouring petrol in after removing the top.

The S.U. Electrical Pressure Pump

Another type of electrically controlled pump which is fitted on present-day cars, is the S.U. pressure electrically controlled type of petrol pump, and it is of the diaphragm type (see Fig. 4).

Construction of Pump

Its action is similar to that of the mechanical pump. Whereas the mechanical pump has its diaphragm operated by a lever in conjunction with the car engine, this pump has its diaphragm operated by means of energising a solenoid coil from the car battery. The lower part of the pump, which is of brass, is the petrol-pumping chamber containing the filter, an outlet and a discharge valve, and two couplings. On top of this chamber is the diaphragm, which produces the pumping action and which also makes a petrol-tight seal between the pumping chamber and the electrical portion of the pump. Fixed to the centre of the diaphragm, by means of a brass disc at the bottom and a steel disc at the top, is a bronze rod which passes to the top of the pump and is screwed into the contact mechanism. The steel disc also acts as the moving armature in conjunction with the pot magnet. Between the pot-magnet

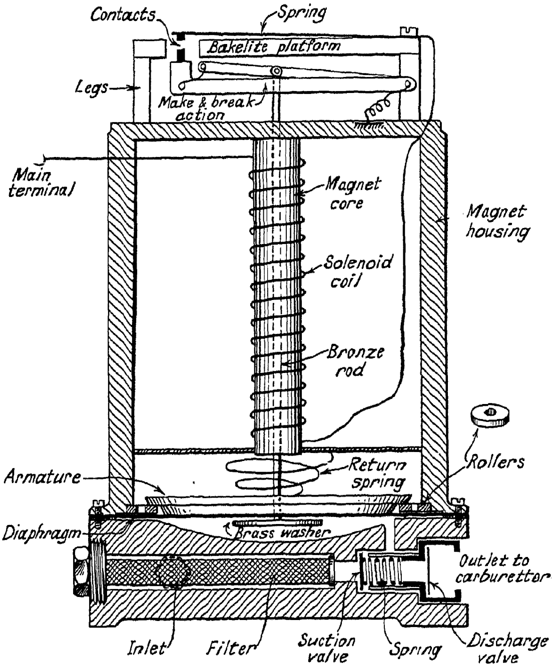


Fig. 4.—S.U. PETROL PUMP
Showing internal construction and connections.

housing and the steel-disc armature are eleven brass rollers or thick washers, which maintain the steel-disc armature in the centre of the pot-magnet housing, irrespective of any variation of the diaphragm. They are also to prevent side movement of the armature, at the same time allowing a free movement in the longitudinal direction. Above the steel armature on the diaphragm is the iron core of the electromagnet, and wound round this is a winding suitable for the applied voltage. On the outside of this electromagnet is a cast-iron housing, completely enclosing the winding.

Make-and-break Action

On the top of this housing is a round bakelite moulding or platform spaced a distance of $\frac{5}{8}$ in. above the cast-iron top of the housing by four bakelite legs. It is for this reason that this bakelite component is often called a four-legged stool. Mounted and fixed on to this platform, and on to the legs, is the entire make-and-break action. Laid flat on top of the platform is a spring strip with a single or a double contact point at one end, whilst the other end is anchored down by a terminal screw. The contact on this spring is facing downwards and is centred over an oblong hole cut away in the platform. Underneath the platform and in line with this contact is another contact fixed on a rocker arm. The other end of this rocker arm is hinged to the outside of two of the four bakelite legs. Also hinged to these two legs, but on their inside faces, is another rocker arm. In the centre of this arm is a screwed pivot, and into this is screwed the bronze rod which passes through the centre of

the magnet and which is fixed to the diaphragm. These two rocker arms are entirely independent of each other, and to transmit the movement of the one with the bronze rod fixed to it, to the other having the contact, the two arms are connected together by means of two small spiral springs.

Internal Connections

One end of the magnet winding is connected to the anchoring terminal screw of the top spring contact, and the other end of the magnet winding is attached to a long screw which acts as the main terminal and which also secures the bakelite cover enclosing the make-and-break action. To complete the circuit, the rocker arm with the contact is earthed to the casting by means of a flexible wire connected to a screw which passes through the bakelite platform to the casting. This screw and another one on the opposite side of the platform hold the platform in its place.

How it Works

When the pump is at normal the two contacts are together, and when the ignition switch on the car is "on," current passes through the magnet winding of the pump, thus energising the magnet core. This magnetisation attracts the steel armature, and as this armature is fixed to the diaphragm, the diaphragm is moved in the same direction, thus causing a vacuum in the pumping chamber. This vacuum draws in petrol through the suction valve into the chamber. Just before the armature has completed its journey to the magnet core, the bronze rod connecting the diaphragm to the rocker arm throws over the make-and-break action and separates the two contacts. The opening of these two contacts breaks the circuit through the magnet coil, and by means of a spring situated between the armature and the end of the magnet winding the diaphragm is forced back to its original position. As it does so, the petrol in the chamber is forced out through the delivery valve into the carburettor. At the end of this stroke the make-and-break action operates again and brings the contacts together, the action being repeated.

When Petrol is not Needed

If the carburettor is not in need of petrol, the diaphragm will not return fully to the end of its stroke, since it will be pressing on the top of the petrol remaining in the pumping chamber. This will leave the contact points in the open position, therefore there will be no current passing through the magnet winding.

Maintenance of Pump

If the pump refuses to work, a test with a voltmeter or lamp connected between the main terminal of the pump and the magnet housing will

verify whether current is reaching this point. If current is indicated here, then by transferring the test lamp, or voltmeter, to the top spring-contact screw, leaving the other test lead on the housing, an indication will show that the magnet winding is complete but that the contacts are open. On the other hand, if no indication is given on this position, it does not necessarily indicate an open circuit on the winding, since, with the contacts closed, these two points are at earth potential. An examination of the contact points will show whether these are making contact or not.

Dismantling Pump

If after this examination the points are seen to be open, it may be that the end of the primary acting rocker arm may be resting on the top of the magnet housing, as this would limit the travel of the rocker arm and prevent it from throwing over. If there is space left between the rocker arm and the top of the housing, the indications are that the distortion of the diaphragm is preventing the complete return of the armature, and this will make it necessary to undo the six fixing screws on the base of the magnet housing and remove the pumping chamber. This will reveal the diaphragm, but it will be found that it is sticking to the magnet housing. With a knife, carefully loosen the diaphragm off the housing, taking care that the brass rollers do not drop out.

Remove the Hinge Pin

The pin which hinges both of the rocker arms to the two legs should then be removed and the pumping chamber refixed again by the six screws. After putting back the hinge pin, if the pump still refuses to work it will be necessary to dismantle the pump again to search for any dirt that may be jamming the moving parts.

Adjustment of Make-and-break

After the pump has been completely dismantled, it will be necessary to reset the position of the diaphragm so that the length of the bronze rod is correct for operating the make-and-break action. To do this, the diaphragm is screwed clockwise as far as it will go and then gradually turned back until a point is just reached when, by pressing on the diaphragm, the rocker arm operates. The diaphragm is then given a further anti-clockwise turn corresponding to four holes. In practice, however, it may be found beneficial to turn the diaphragm back for five holes.

Testing the Pump

The testing procedure for this pump is similar to that of the mechanical pressure pump. The pump is fixed to the test stand and the two rubber hose pipes are connected to the inlet and outlet couplings of the pump.

Make sure that the outlet of the pump is connected to the sight-glass side of the test stand. If the pump is connected to a battery of the correct voltage the pump should commence to deliver fuel. This can be verified by looking through the sight glass (see Fig. 2).

Pressure of Pump

A pressure of 2 to 3 lb. per square inch should show on the gauge, and with the stopcock turned off and the pump disconnected from the accumulator this pressure should remain for several minutes, providing the valves are seating properly and that there are no air leaks in the pipelines or couplings.

Faults indicated by Noise

A noisy pump, whether electrically or mechanically operated, is a sure sign of an air leak in the suction side. Make sure that all joints are tight, and also see whether there is petrol in the tank. If the pump operates correctly but does not deliver petrol, remove and examine the valves for dirt or split seating. A slow-acting pump may be due to a blockage in the pipeline, or else to a choked filter.

Pump gets Hot

Working under these conditions the body of the pump will get hot, since the winding will be in circuit for longer periods.

Burnt Contacts

If the resistance which is connected across the winding breaks down, severe sparking will take place at the contacts. Another cause for sparking is the malalignment of the rocker-arm springs, which causes the contact points to wear at the sides instead of allowing the points to meet fully and squarely with each other. Yet another cause of severe sparking is the use of a 6-volt pump on a 12-volt circuit. This is a simple mistake to make although the pumps are stamped with the voltage on the top of the bakelite cover.

Colour Coded

These covers are also coloured to distinguish between 6- and 12-volt units, but when many pumps are lying about on the test bench, the covers are liable to become mixed. There is no need to be concerned about this happening, since the coil leads are also colour coded. When any doubt exists regarding the voltage of the pump, an examination of the ends of the coil where they emerge out of the magnet housing will decide. A 12-volt pump has a black cover and red sistoflex leads, whereas a 6-volt pump has a brown cover and green sistoflex leads.

Later articles in this volume deal fully with the servicing and maintenance of all the leading types of fuel pumps.

SERVICING PACKARD SIX, EIGHT, AND SUPER EIGHT, 1937-9

THE ELECTRICAL EQUIPMENT

ON 1937 cars, Autolite or Delco-Remy 6-volt equipment was standardised, with earthed positive pole and ventilated dynamo with combined current voltage regulation. Different units are fitted to each of the three models, but all include solenoid starter switch, panel reading and beam indicator lamps, and twin horns (relay operated).

Charging Circuits

Dynamos are 3-brush type, with non-adjustable field brush, wired to regulator, the cut-out unit having shunt and series windings.

Dynamo *A* terminal is common to the armature and field (live negative). Terminal *F* is field positive, and "*GRD*" is "ground" or earth. *F* terminal is wired to field terminal of regulator where the circuit is completed to earth via closed contacts with parallel resistance. Note that field current traverses the series winding of the right-hand regulator unit and through both pairs of contacts in series.

When ignition is switched on, the shunt winding of this regulator is energised. As the dynamo builds up voltage, the cut-out closes, and current from terminal *A* passes through the cut-out series winding, closed cut-out contacts, and both series windings of centre regulator to battery line. Voltage rise on the "ignition" shunt winding of right-hand regulator (battery volts on charge) attracts armature, separating the points and by-passing the field current to earth via resistance. The field-current rise energises the series winding with the same effect. The centre regulator operates when the main current exceeds 28–30 amps.

Do not test on open circuit, as there is no dynamo voltage control. Pressure on load between terminals "*GEN*" and "*GRD*" should be 7·45–7·55 volts with dynamo and regulator hot.

To increase the voltage, tension the spring by bending lower spring hanger. The air gap should be 0·06–0·07 in., with fibre bumper barely touching contact spring post. Contacts should open 0·015–0·25 in. (Adjust by bending armature stop.) Gap between fibre bumper and contact spring post, with armature up, should be 0·008–0·013 in. (Adjust by bending upper armature stop.) Contact pressure, 3½ oz. at moment of

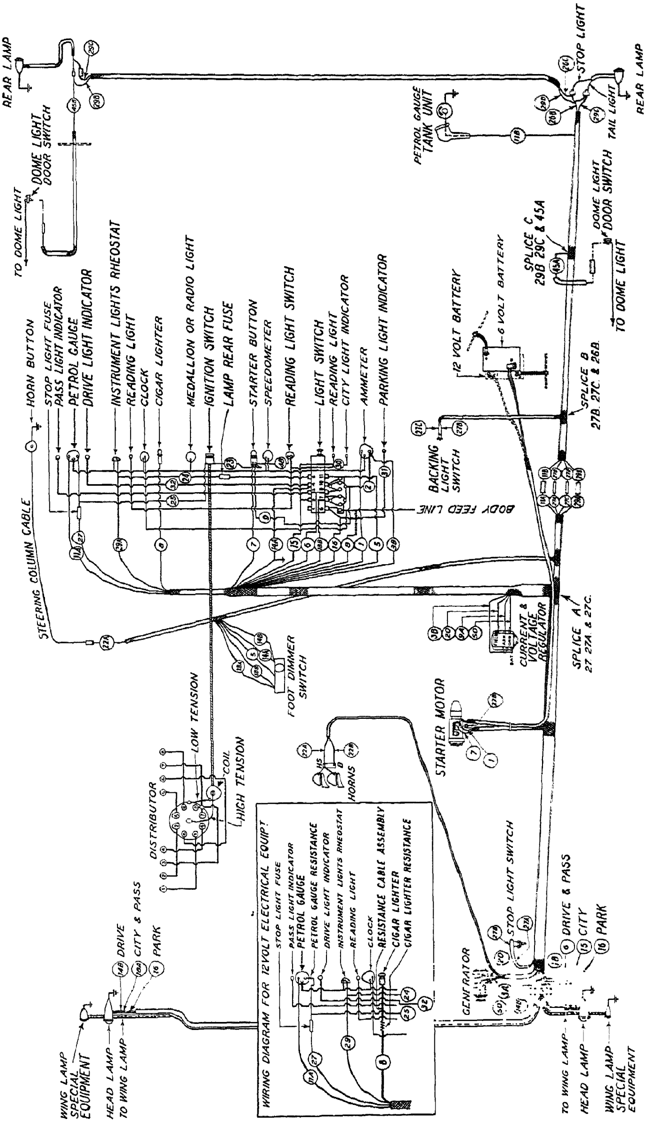


Fig. 1.—WIRING DIAGRAM, PACKARD SUPER EIGHT (1937-8)

opening. (Bend upper contact spring to adjust.) Cut-out closes at 6·5–7 volts. Air gap, 0·018–0·022 in., points closed. Contact gap, 0·018–0·025 in.

To avoid breaking the seals, check dynamo first by earthing *F* terminal when charge should register. If no charge is indicated, disconnect cables and repeat with voltmeter between *A* and *GD*: voltage reading now showing exonerates dynamo. Check wiring for earths or replace regulator. Verify battery voltage between regulator terminals "*Batt*" and "*GRD.*"

Lighting Circuits

Cars in this country have side lamps wired in parallel with rear. The push-pull panel switch controls all lights, headlamps having a thermostatic circuit-breaker in series, which operates by heat distortion of bimetal blade. A 20-amp. fuse protects rear lamp (and side lamp) lines, and a second 20-amp. fuse is incorporated in accessory feed.

Headlamps have dual-filament bulbs controlled by foot dimmer switch. Also connected to the switch are panel indicator lamps to show beams in circuit. Reading lights are fed via ignition switch together with stop lamps and fuel gauge. Roof lamps and cigar lighter are fed via accessory fuse.

Auxiliaries

Accessories are fed via 25-amp. fuse on lighting switch, and fittings vary according to model. Radio is wired separately from ammeter with separate fuse. The defroster and heater are controlled by separate switches and fed via the ignition.

Horns

Horns are connected in parallel to the relay unit. Feed is via cable 21 from battery terminal of starter switch, and cable 20 connects the relay to steering-wheel button. If horns fail, earth the *S* terminal of relay when response of horns indicates break in button cable or faulty button. Connect *B* terminal to the horn feed. If horns are now sound, relay is faulty. (A click on pressing button indicates relay solenoid movement but faulty contacts.)

Starter

The starter solenoid switch is provided with a button for manually closing main contacts if failure occurs. Check panel push and wiring by bridging terminal 7 *A* to battery terminal, when solenoid and starter should operate.

12-volt Equipment

Cars fitted with 12-volt Autolite equipment have the same general arrangement as 6-volt installations. Two resistances are incorporated,

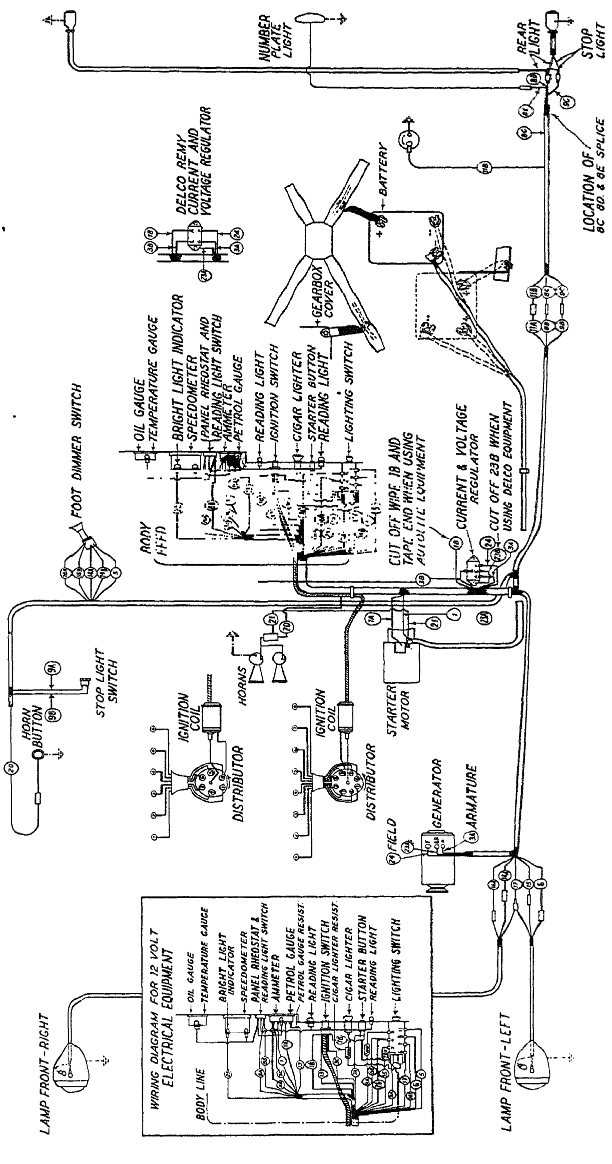


Fig. 2.—WIRING DIAGRAM, PACKARD SIX AND EIGHT (1937-8)

one in series with the feed cable to petrol gauge, and the other in line to cigar lighter, these units being identical with those fitted to the 6-volt equipment.

The Petrol Gauge

In the case of the petrol gauge, note that cable No. 27 is connected to the feed side of resistance, this being connected in the gauge circuit only. The cable enters a harness, and two splice joints are made inside chassis harness, one feeding stop-light switch and the other the reverse-light switch, these units receiving 12-volt feed.

In the case of the cigar lighter, resistance is in series with No. 8 cable connected to auxiliary fuse. A second cable from the same fuse feeds body circuits, roof lamps, and the like. The foregoing applies to Super Eight models.

In Six and Eight models, petrol gauge resistance is in series with No. 13 cable feed from ignition switch, cigar-lighter resistance being in line from fuse to lighter.

All other equipment is designed for direct 12-volt working. The voltage and current regulator unit operates at about twice the figures given for 6-volt units. Dynamo voltage should therefore be about 15–15·6 when charging.

HOW TO READ AND USE CAR-WIRING DIAGRAMS

By E. T. LAWSON HELME

TO the automobile electrician, the ability to read, draw, and understand a circuit diagram is important. A definite code of symbols with universal meanings has been evolved to indicate certain features and, although diagrams vary in complexity from a simple technical layout to the latest American practice of photographic plans, the symbols always indicate specific combinations.

The Pictorial Diagram

Some diagrams are more informative and comprehensive, according to the uses they are intended to serve. A pictorial layout, such as may be found in the majority of instruction books issued for car owners, shows the terminals to which each wire is to be connected.

A system of colour identification is used on all modern cars, the braiding carrying the colour combination being extended throughout the whole length of the cable concerned. The code is usually indicated in the diagram, and although the relationships of colour and circuit are not the same in all models, any given colour is associated with the whole of the circuit to which it applies.

For example, red is commonly used for side- and rear-lamp wiring, and it will be found that all wiring serving these sections is similarly marked, starting from the feed terminal of the switch and continuing to each destination, including all connections to fuse-box, etc.

The Technical Diagram

The other extreme in wiring diagrams is a technical diagram in which all pictorial representations are replaced by symbols, wiring being indicated by direct lines, not necessarily drawn to show the disposition of wiring on the vehicle. Colour coding and marking is largely dispensed with, the identification of circuits being obvious from the manner in which they are drawn.

Each type of diagram serves its individual purpose, the most useful from all viewpoints being a combination of the two types, from which may be discerned the internal connections of unit components, and also the disposition of circuits, terminal markings, and colour identification of cables in harness, and other data embodied in pictorial layout.

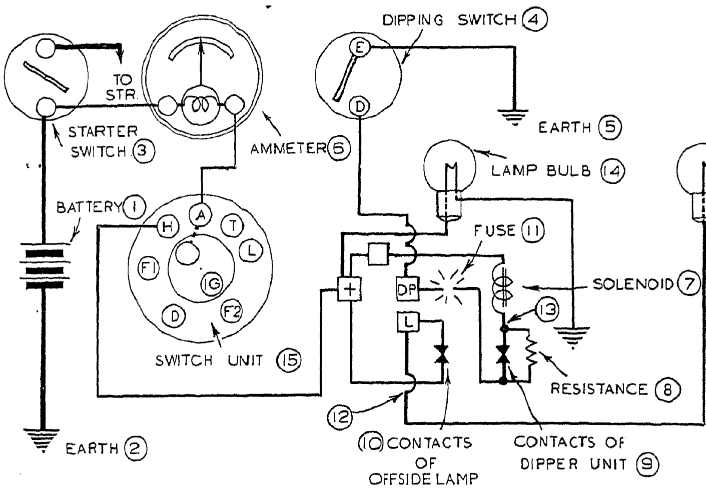


Fig. 1.—CIRCUIT DIAGRAM, SHOWING ARRANGEMENT OF STANDARD HEADLAMPS WITH DIPPING REFLECTOR IN THE NEARSIDE LAMP

How to Read a Diagram

Fig. 1 is an example of a circuit diagram containing specimens of both technical and pictorial presentation. It shows the arrangement of standard headlamps with dipping reflector in the nearside lamp, the offside lamp being controlled through the dipper unit. The numbered arrows indicate features of the diagram which, by the way in which they are drawn, convey definite information.

The Battery

The battery (1) is shown by alternate light and heavy lines, each pair representing the positive and negative groups of one cell. The longer thin lines represent the positive groups and the shorter thick lines the negative groups.

Earth

Thus the diagram shows that a 6-volt battery of three cells is fitted, with the negative end terminal connected to the chassis, frame, or "earth"—as indicated by (2).

Starter Switch

The positive-end terminal of the battery is connected by heavy starter cable to the starter switch (3), the thick line indicating starter circuit to this point. The diagonal line drawn between the starter-switch terminals has a significance in that it shows the switch to be double-pole

type—that is, the bridging contact is held off both terminal contacts simultaneously when the switch is "open."

Dipping Switch

Compare this with the dipping switch (4), where the diagonal line is in contact with the terminal connected to earth at (5). This means that the "make" and "break" of the switch is between the dipper terminal D and the bridging contact only, the switch being of the single-pole type.

Single- and Double-pole Switches

In practice, this difference is important: Supposing that we wish to test the insulation between the switch terminals and the metal body of the switch. In the case of the dipping switch, it does not matter whether the switch is "open" or "closed" when the test is made, as the moving-bridge member is attached to the E terminal and its insulation to frame is simultaneously tested with it. Where the starter switch is concerned, however, both terminals may be tested to frame and found clear of faults, but as the moving-bridge member is isolated when the switch is "off" or open, insulation breakdown between this and the frame will not be detected, unless the switch is held closed during the test, when both terminals will indicate a fault.

The Ammeter

The ammeter is shown semi-pictorially at (6), but the spiral line joining its terminals is a symbol indicating a solenoid or electro-magnetic winding.

The Solenoid of the Dipper Unit

The winding of the ammeter is a plain helix with no iron core, but the solenoid of the dipper-unit—indicated at (7)—is wound on an iron core, this being shown by the two adjoining lines (sometimes the spiral line is drawn surrounding the parallel lines which indicate the iron core).

Resistance

The zigzag or wavy line means a resistance or resistive winding with no magnetic induction, as at (8), the resistance of the dipper unit.

How Contacts are Shown

Contacts are shown in a variety of ways, the dipper contacts (9) and offside lamp contacts (10) being shown in one of the simplest forms.

Fuse

Where a break in the line, with surrounding radial lines, is drawn, as at (11), a fuse is understood to be inserted. Another method of indicating a fuse is by two circles connected by two crossed lines; as shown in Fig. 2.

Cable Connections and " Cross-overs "

Where one line is shown crossing another by a loop, as indicated at (12), the two lines so drawn have no electrical connection, and have no actual cross-over, but the symbol serves the convenience of drawing. An electrical connection may be indicated as at (13), where one line abuts on the other.

Lamp Bulbs

Lamp bulbs may be shown by a plain circle, a helix, or detailed as (14), from which we learn that centre-contact single-filament bulbs with earth return through the caps are used.

Pictorial View of Switch Unit

The rear view of the switch unit at (15) is purely pictorial, as it shows the relative terminals and markings but does not indicate internal connections or bridging, nor does it inform us what switching combinations are employed.

The Meaning of " Series " and " Parallel "

The terms " series " and " parallel " are commonly used in describing electrical circuits : a clear understanding of how they are applied is very necessary. Briefly phrased, when two or more parts of a circuit are connected in a continuous path they are in series, and when these parts are all individually connected between the terminals of the supply they are described as " in parallel," or, as it is sometimes said, " shunted across " each other. In series connection, the current flowing through all components is governed by the total resistance of the composite circuit, while in parallel connection each component receives nominally the terminal voltage of the supply and passes current in proportion to its individual resistance.

Examples of these connections are seen in Fig. 1 in the dipper unit, where current flows through the solenoid (7), resistance and contacts (8) and (9) together, and the fuse, in series. The resistance and contacts, although in series with the circuit, are in parallel with each other, or in " parallel-series " with the circuit.

The headlamps are in parallel with each other, both being connected to the positive terminal of the dipper unit and both having earth-return connection through bulb caps, but the offside lamp has the lamp contacts (10) in series.

It should also be noted that every circuit is complete, starting at the battery positive terminal and finishing at the earth connection, with common return through the frame to battery negative terminal.

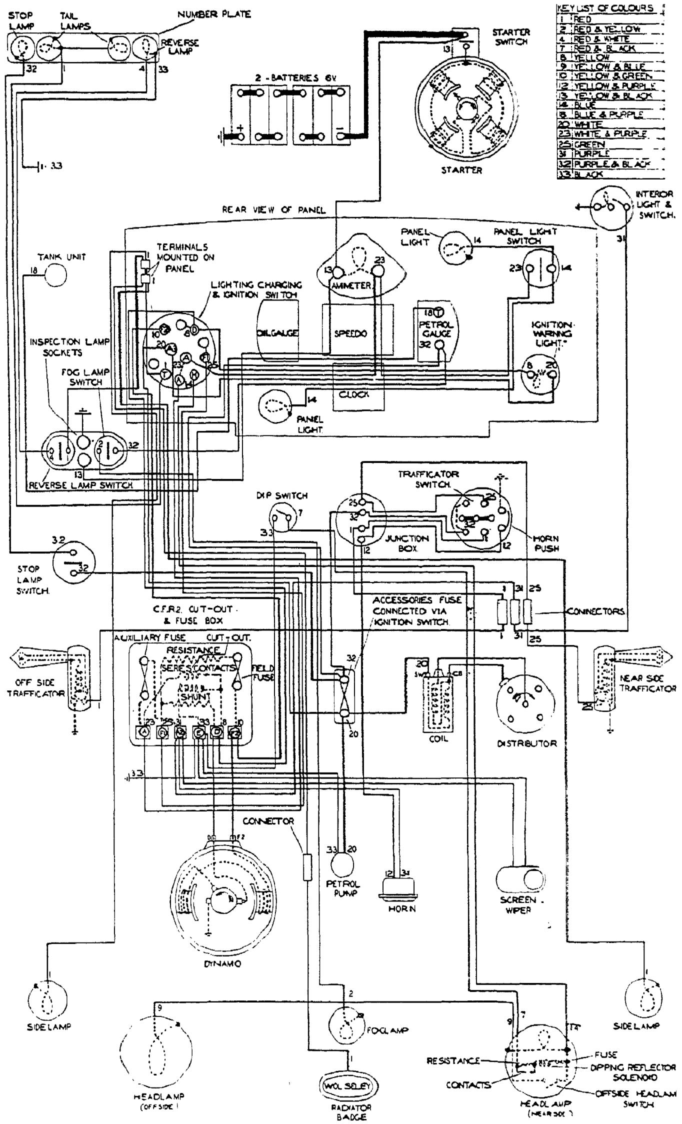


Fig. 2.—A TYPICAL WIRING DIAGRAM FOR CAR WITH THIRD-BRUSH DYNAMO

Showing the Lucas 12-volt electric lighting, starting, and coil-ignition equipment on the Wolseley 10/40 h.p. and 12/48 h.p.

TRACING CIRCUITS

We have explained some of the symbols met with in car-wiring diagrams and have traced out a typical car-lighting circuit. It is necessary, however, if we are to find our way about a complicated car-wiring diagram, to consider the other sections of the electrical system. The best method is to subdivide the complete electrical system broadly into five sections:

(1) The battery-charging circuit.
(2) The starting-motor circuit.
(3) The ignition circuit.
(4) The lighting circuit.
(5) The accessory circuit.

THE BATTERY-CHARGING CIRCUIT

The battery-charging circuit comprises :

(1) The battery.
(2) The dynamo.
(3) The cut-out and fusebox.
(4) The regulator, if any.
(5) The ammeter.
(6) The charging switch and wiring interconnecting the components.

The circuit starts at the positive main brush of the dynamo and enters at the positive terminal of the battery. If the positive terminal of the battery is earthed, the positive dynamo brush is also earthed, the car chassis providing the positive path from the dynamo to the battery. If the negative of the battery is earthed, then the car chassis provides the negative return from the battery to the dynamo negative brush.

Third-brush Dynamo

A glance at the field circuit of the dynamo will tell us whether it is a two- or three-brush machine.

A machine with three brushes will indicate that the current output is automatically regulated and kept practically constant by third-brush control (*see* Fig. 3). We should then see if there are any resistances in the field circuit, located either in the dynamo itself or in the fusebox. If so, they will probably be controlled from the lighting, charging, and ignition switch on the instrument panel. Changing the position of the switch alters the amount of resistance in the field circuit of the dynamo, reducing or increasing the charging current to the battery. The switch is usually arranged to give high and low charge, and when the head-lamps are switched on the dynamo is connected to give its maximum output (*see* Fig. 4).

Alternatively, we might find other modifications of the third-brush control, as described on pp. 6–10.

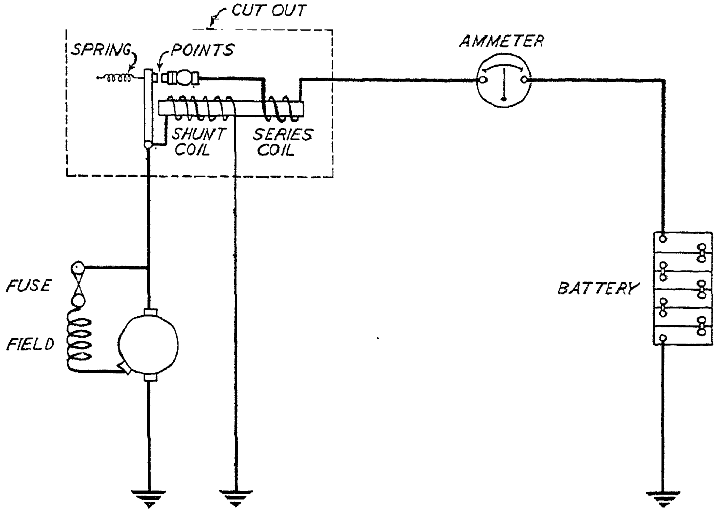


Fig. 3.—DIAGRAM OF A COMPLETE CHARGING CIRCUIT WITH A THIRD-BRUSH MACHINE

The cut-out is shown in semi-pictorial form, to illustrate its operating principle. Compare with the technical diagram of the cut-out in the next Fig. and Fig. 2.

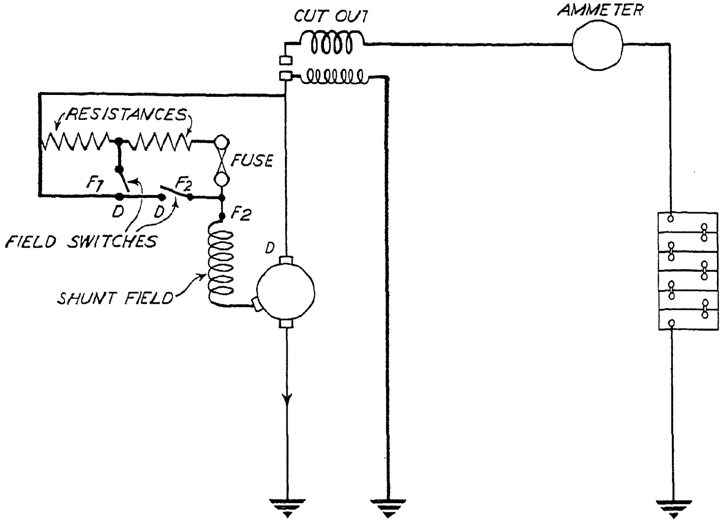


Fig. 4.—DIAGRAM OF A CHARGING CIRCUIT WITH A THIRD-BRUSH MACHINE WITH FIELD SWITCHES

This is the circuit diagram as traced out from the actual car-wiring diagram in Fig. 2, the field switches being incorporated in the lighting, charging, and ignition switch. Their operation varies the amount of resistance in the field circuit and thus the charging rate of the dynamo. Low-charge position: F1 and F2 off. High-charge position: F1 on, F2 off. Maximum output (headlamps on): F2 on, F1 off.

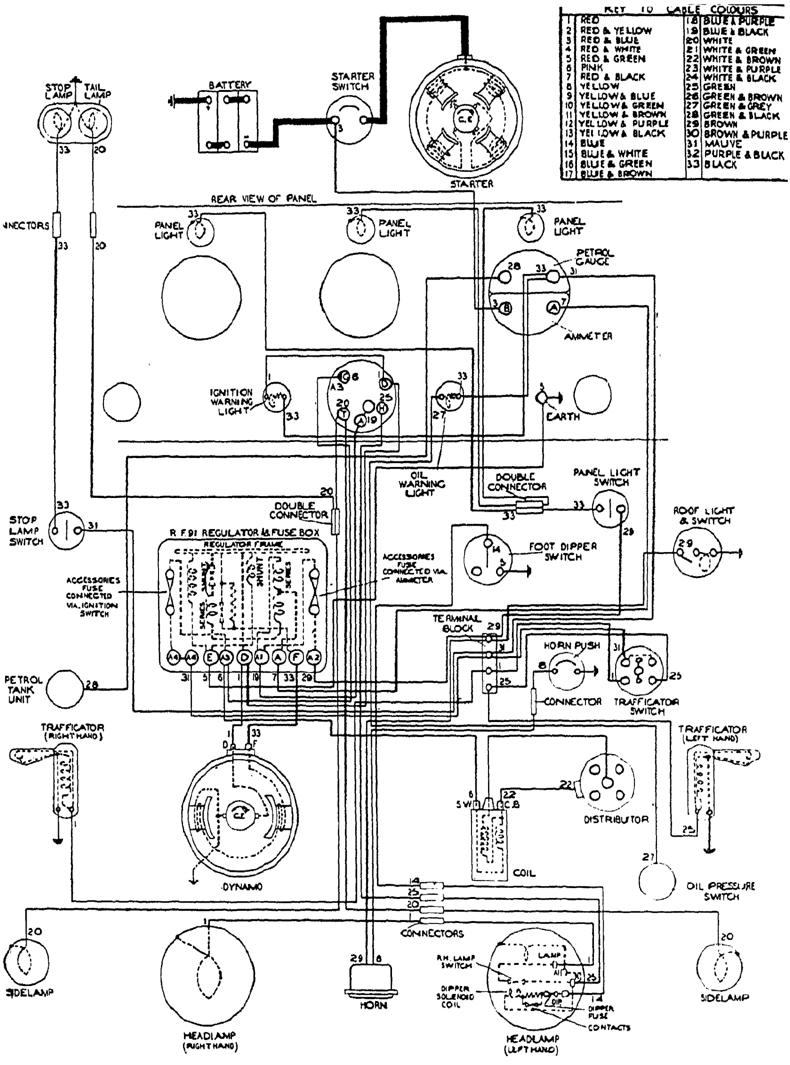


Fig. 5.—TYPICAL WIRING DIAGRAM FOR CAR WITH TWO-BRUSH DYNAMO AND CO VOLTAGE CONTROL (VAUXHALL 10 H.P.)

The Cut-out

An automatic cut-out is an essential component in any charging circuit, and its purpose is to prevent the battery discharging back through the dynamo when the engine is stationary or operating at slow speeds.

The cut-out consists of a soft-iron core with two windings—one a voltage winding of fine wire and the other a series winding of heavier wire. The fine-wire winding is connected across the dynamo terminals. This winding is, therefore, excited whenever the dynamo is generating any current at all. The heavy-current winding is a series winding through which the current between the dynamo and the battery passes when the cut-out points are closed. With closed points the battery-charging circuit is completed.

Fig. 3 gives a diagrammatic representation of a charging circuit with a third-brush machine.

If the dynamo speed drops to a point where the voltage of the dynamo is less than the voltage of the battery a reverse current would tend to flow. Immediately this happens, however, an opposition will be set up between the shunt coil on the cut-out and the series coil. Since the dynamo voltage is low the effect of the shunt coil is weak, the result being that the series coil will change the polarity of the cut-out core, demagnetising the cut-out core, releasing the plate and opening the cut-out.

Two-brush Dynamo

If the diagram indicates a two-brush dynamo, we may expect to find an external regulator (combined with cut-out) for controlling the voltage and/or current of the dynamo. There are many types of regulator to be found, as will be seen from pp. 2–6.

An example of a charging circuit incorporating a compensated voltage regulator, which automatically varies the output according to the load on the battery and its state of charge, irrespective of the speed of the dynamo, is shown in Fig. 6. The regulator is combined structurally with the cut-out. The two units are, however, electrically separate, employing separate armatures, though they possess field systems which are common over a portion of the magnetic path. The regulator windings consist of a shunt or voltage winding connected directly across the dynamo, and two series or current windings, one of which carries the full current from the dynamo to the battery, while the other winding carries the current of the lighting, ignition, and accessory loads. These coils assist each other in energising the magnet system and thus in affecting movement of the armature.

When the dynamo voltage reaches a value determined by the state of charge of the battery, the magnetic field due to the voltage winding becomes sufficiently strong to attract the armature. This causes the contacts to open, thereby inserting the resistance in the field circuit. This reduction in field current lowers the dynamo voltage, and this, in

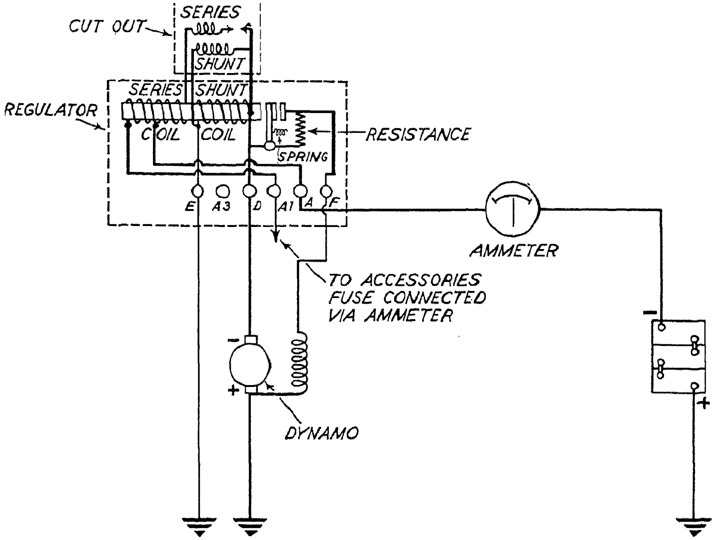


Fig. 6.—CHARGING CIRCUIT OF CAR WITH TWO-BRUSH DYNAMO WITH COMPENSATED VOLTAGE CONTROL

The regulator is shown in semi-pictorial form. Compare with the technical diagram, Fig. 5.

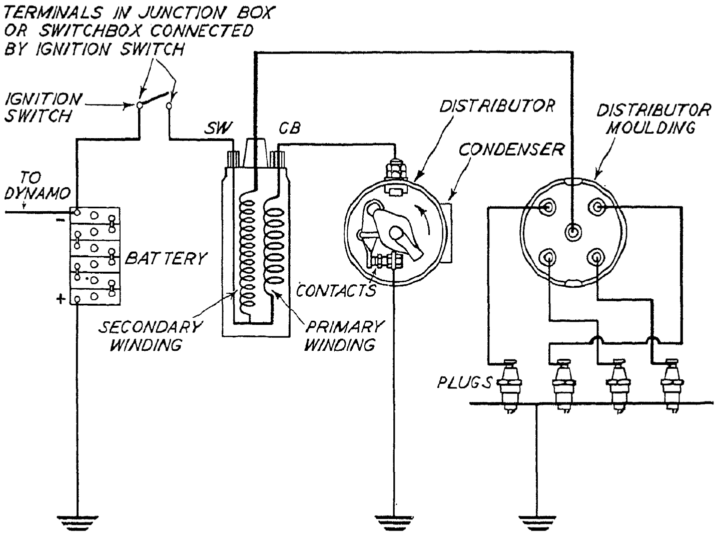


Fig. 7.—A TYPICAL COIL-IGNITION CIRCUIT

turn, weakens the magnetic field due to the voltage coil. This allows the armature to return to its original position, thus closing the contacts, so that the voltage returns to the predetermined maximum. The cycle is then repeated and the armature is set into vibration.

As the speed of the dynamo rises above that at which the regulator comes into operation—about 20 m.p.h.—the dynamo output undergoes practically no increase.

THE STARTER CIRCUIT

The purpose of the starter is to provide the initial turning of the car engine for starting. The current taken by an average starter is from 150 amps. up to 400 or 500 amps. if the engine is cold or stiff. Since the dynamo output on the average car is from only about 8 to 20 amps., the starter must take its supply from the battery, which must be so constructed as to deliver the requisite heavy amperage.

The ammeter on the dashboard is never connected to record the starter current.

In the simplest form the complete circuit is from the battery positive terminal to earth (assuming a positive earth system), from earth to the positive brush, armature, the series-parallel field windings, starting switch, and battery negative (*see* Fig. 2).

A refinement of this circuit is the remote-control system illustrated in Fig. 10. In this case only a small current flows through the button switch, this current being used to energise an electro-magnet which closes the main starter switch, which is usually built on to the starter motor.

THE IGNITION CIRCUIT

The modern car is provided with battery and coil ignition, which it will thus be appropriate to consider. The circuit is from the positive battery terminal when the car is stationary or running at slow speeds, or from the positive dynamo terminal when the dynamo is running at a speed sufficient to charge the battery. The complete connections are given in Fig. 7. There are two circuits, namely, the primary and secondary.

The Primary Circuit

This circuit consists of battery, switch, primary winding (of the high-tension coil), and contact-breaker, all connected in series.

In the single-pole system now universally adopted, one pole of the battery (either positive or negative) is connected to "earth," i.e. the metal frame of the car. The fixed contact of the contact-breaker is also the one usually earthed.

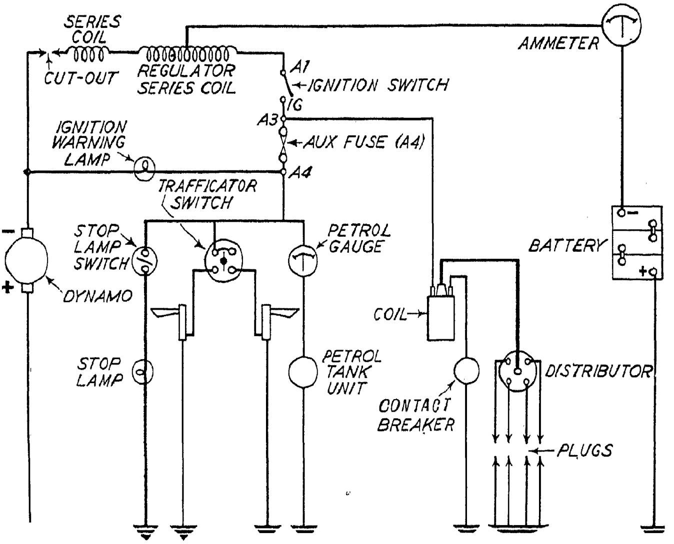


Fig. 8.—THE COMPLETE IGNITION CIRCUIT OF CAR FITTED WITH COMPENSATED VOLTAGE-CONTROLLED DYNAMO

Note the accessories connected via the ignition switch.

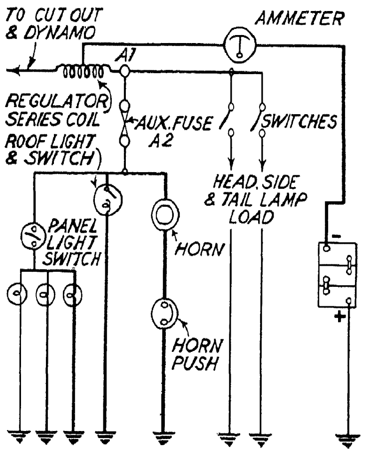


Fig. 9.—LIGHTING AND ACCESSORIES CONNECTED VIA THE AMMETER ON CAR FITTED WITH COMPENSATED VOLTAGE-CONTROLLED DYNAMO

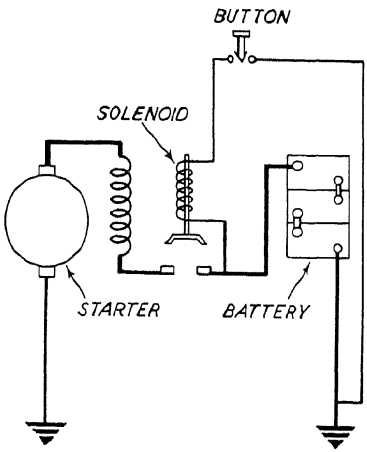


Fig. 10.—DIAGRAM OF REMOTE-OPERATED STARTER CIRCUIT

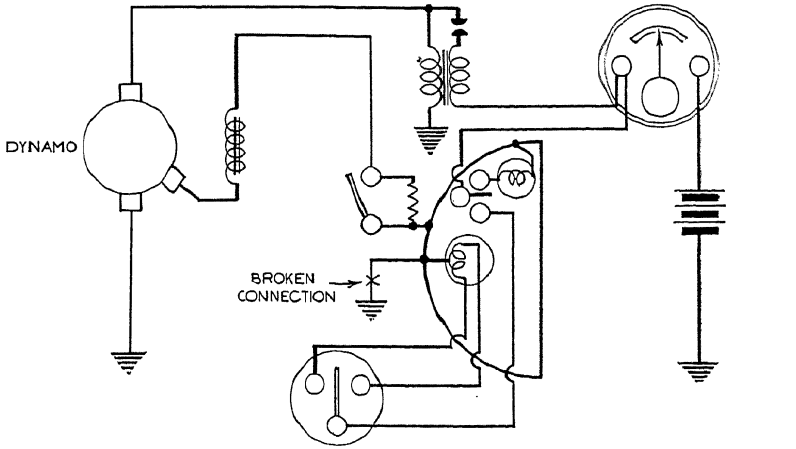


Fig. 11.—A PRACTICAL EXAMPLE OF USING A CIRCUIT DIAGRAM IN TRACING A FAULT

The Secondary Circuit

The secondary circuit consists of a very large number of windings of fine wire in series with the rotating arm of the distributor and, at its other end, connected to one end of the primary coil. The sparking plugs are in turn connected by means of the rotating distributor arm and its contacts to the secondary coil, the circuit being completed through the "earthed" side of the sparking plug; the outer metal shell of the latter is in metallic contact with the engine and thence to the frame of the car.

HOW TO USE A CIRCUIT DIAGRAM IN TRACING A FAULT

Fig. 11 is a practical example of using a circuit diagram in tracing a fault. A motor-cycle, left standing with lights on, is found, on restarting, to develop a fault which causes cut-out sparking, which disappears when the cut-out contacts are held closed by hand. The machine functions normally when no lights are in use. On checking the dynamo voltage, this is found to have reversed polarity, but is corrected by exciting the field through the cut-out. How does the dynamo field become reversed when lights are in use, but not otherwise ?

On inspection we find that both headlamp and pilot lamp earth connections are made to the lamp shell. The dynamo, battery, and cut-out are earthed direct to the frame. Signs indicate that battery current is flowing back through the field to third brush and frame via armature, but only when lamps are in use, therefore the field must be in series with the lamps. The diagram is purposely simplified, representing only the sections affected. If the connection between lamp shell and frame has

inefficient conductivity, introducing unwanted resistance into the lamp return circuit, current can reach the frame by flowing through charge resistance and switch in parallel (if closed), via field cable to winding and earth. In so doing, the field coil is energised in the reverse direction to that which obtains when connected across the armature in the normal way, with the result that, residual magnetism being reversed, the dynamo builds up reversed voltage and causes sparking at the cut-out contacts until this is corrected.

The Use of Rough Circuit Diagrams

A puzzling fault will often become clear if a rough diagram—the simpler the better—is made of the installation as it appears, when the eye can follow alternative current paths, noting the possible effects in each circuit—in fact, building up a fault circuit to fit the symptoms of the case. This will establish a line of investigation which can be followed with far better chance of successful results than unsystematic searching, possibly in sections of wiring or circuits which, if seen in diagram form, would be obviously exonerated from connection with the fault.

The practice of studying circuit diagrams will enable the electrician to learn much in advance about systems he may not yet have handled.

WIRING FAULTS

TESTING AND PRACTICAL ADVICE ON REPAIR

By E. T. LAWSON HELME

THE wiring of a vehicle electrical installation forms the inter-connecting linkage between the various units, which must, of necessity, be located at various positions on the vehicle according to their respective functions. A central switch or control box is the converging point where the various conductor lines meet and are connected to suitable circuits, and from which the units connected to the remote ends of the cables may be operated.

WIRING SYSTEMS

In practice two systems are used, with a third, combining the first two, occasionally to be met with. Each has individual fault possibilities, and a knowledge of what may be expected is of great help in tracing faults.

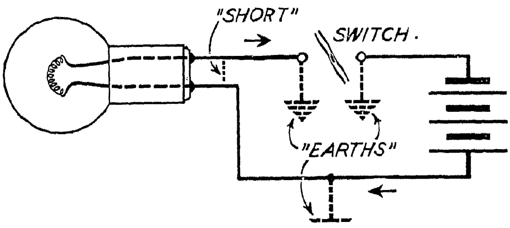
Double-pole System

The double-pole system—now largely discontinued on passenger cars—is still employed in many commercial installations. It provides two separate insulated cables, one for outgoing current and the other for the return circuit, to each unit—neither cable being connected to the chassis. A switch in series with one of the lines controls the unit. Fig. 1 shows a simple lamp and battery wired in this manner.

Single-pole System

The single-pole system, in almost universal use on private vehicles, provides a single insulated cable to carry outgoing current, the return circuit being provided by the frame of the car and the body of the unit which is attached to it. One terminal of the battery is connected to the chassis and the corresponding terminal of every unit is similarly " earthed " or " grounded "—terms which mean electrical contact with the chassis. Usually the switch and fuse (if fitted) are in series with the " live " conductor, as shown in the layout of lamp and battery in Fig. 2. A combination of the two systems is sometimes made for convenience in order to by-pass unsuitable chassis contacts, and the switch may equally well be in the earthed line, as shown in Fig. 3.

The tendency nowadays is to connect the positive terminal of the battery to the earth, known as the positive earth system of wiring, or



1.—Double-pole or insulated return wiring system

The dotted lines show possible faults.

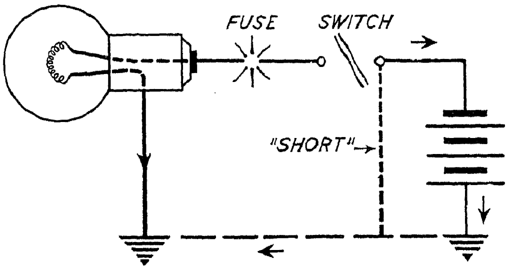


Fig. 2.—Single-pole wiring system

One terminal of the battery being connected to the chassis. The dotted line shows position of a fault, as referred to in the text.

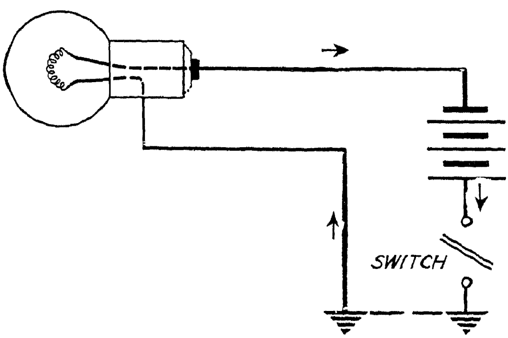


Fig. 3.—Single-pole system with switch inserted in earthed line

positive return. Compared with the negative connection to earth, this system reduces corrosion of the battery terminals, and increases the effective life of sparking plugs, coil windings, and the distributor rotor, owing to lower electrical stresses.

Short-circuits and Open Circuits

Taking these systems in the simplified form, let us classify all possible faults, with their effects and methods to be used in tracing. A "short-circuit" comprises an unintended by-pass or path by which current may return to the battery. The severity of the short depends on the mechanical cause and the added conductivity, varying from a damp insulator surface, which may pass a few micro-amperes, to a direct metallic contact across the battery terminals, in which the magnitude of current flow would be limited only by the capacity of the battery to sustain the overload. An "open circuit" consists of an unintended resistance in the path of the current, restricting its value below normal. This may also vary from a badly made connection, which becomes hot, to a complete break in the wire, rupturing the circuit completely.

Position of the Fault and its Effect

The position of a fault decides its effect upon the performance of the circuit. For example, a "short" across the lamp terminals in Fig. 1 would have no effect until the switch was closed, when the added conductivity or reduced circuit resistance would cause an abnormal current to flow and the applied voltage would fall in proportion. A short across the switch terminals, however, would only render the switch ineffective ; it could not cause increased current consumption, this being governed mainly by the resistance of the lamp filament.

If the short occurred across the battery terminal of the switch and "earth," as sketched in Fig. 2, its effect would be apparent whether the switch were open or closed, as the circuit then afforded is on the "live" side of the switch and therefore unaffected thereby.

An unintended earth contact is another form of short, its position governing effects. In Fig. 1 an "earth" on either switch terminal would not affect operation, unless another earth became established on the return line, when the two would form a short path, by-passing the lamp, the effect of switch operation depending on which switch terminal had become earthed.

These simple illustrations indicate the basic principles of fault location, and should be thoroughly grasped by the student.

The existence of a fault is known only by its effects, and we have to work back from effects, taking into consideration all "clues" afforded by switch operation, isolating of sections, etc., until the original cause of the fault is located.

Constant and Intermittent Faults

When dealing with a definite fault of a constant nature, which manifests itself whenever the circuit is in operation, tracing is simplified and reduced to a systematic procedure of eliminating possible paths until the section at fault is found. If the trouble is intermittent, only occurring under certain conditions, tracing is rendered more difficult, especially if the contributory conditions cannot be reproduced at will, or are undefined. It often happens that a fault of this nature gives inconclusive evidence, such as a short carrying a very small current, insufficient to visibly affect set performance beyond causing the battery to discharge slowly over a period when there should be no circuit across it, and therefore no discharge.

Methods of Fault Testing for Short-circuits

There are two methods available in testing, and these can be used according to the nature of the fault.

Fig. 4 illustrates the first, in which a battery of the voltage normally used is employed, together with a sensitive instrument in series. A good voltmeter, known to be sensitive to small currents, is an excellent instrument for the purpose, as, in addition to its ability to indicate

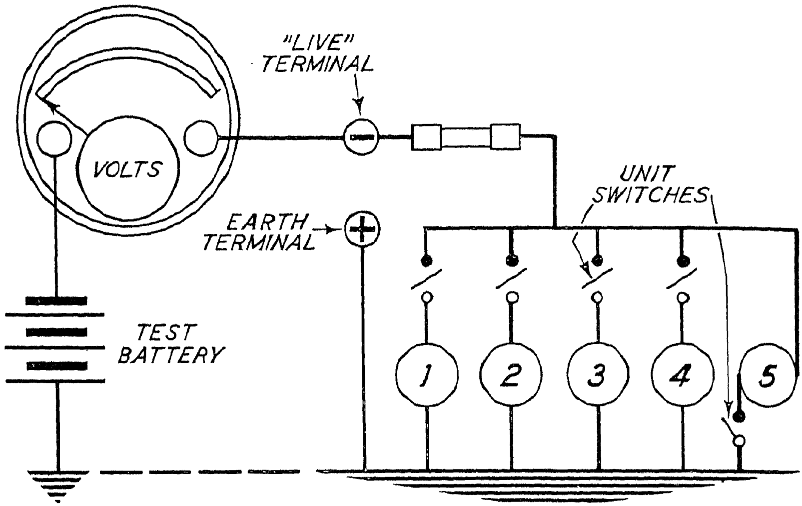


Fig. 4.—TESTING FOR SHORT-CIRCUIT
Using a voltmeter as a resistance-limited milliammeter, and a test battery.

minute current leakages, no damage is occasioned if a path of high conductivity is closed across the circuit, the meter passing only the normal current it draws at the voltage applied. The test circuit is shown connected to the common terminals of a number of accessory circuits protected by a single fuse. If we find that the fuse blows immediately it is connected in the circuit we know from this that a short exists which is unaffected by switches and must therefore be situated at some point on the live side of the switches.

With the test circuit connected as shown, the voltmeter, which is now functioning as a resistance-limited milliammeter, will read a value closely approximating the applied battery volts when a new fuse is inserted. The effect is the same if the vehicle battery is normally used and the meter connected across the fuse clips in place of a fuse.

We now disconnect, one by one, the lines in parallel with the supply until the reading falls to zero, when it is obvious that the last line disconnected carries the fault. Supposing circuit No. 2 in Fig. 4 is located as the culprit, it is now necessary to narrow down the locality, which is done by reconnecting No. 2 cable to the fusebox terminal and disconnecting the other end of the cable at the switch (switch terminals on live side marked in black). If the reading continues, the location has been passed, and it is necessary to work back along the cable, inspecting it for insulation damage allowing the conductor to touch earthed metal. When the fault is disturbed, the reading will fall to zero. On the other hand, if dis-

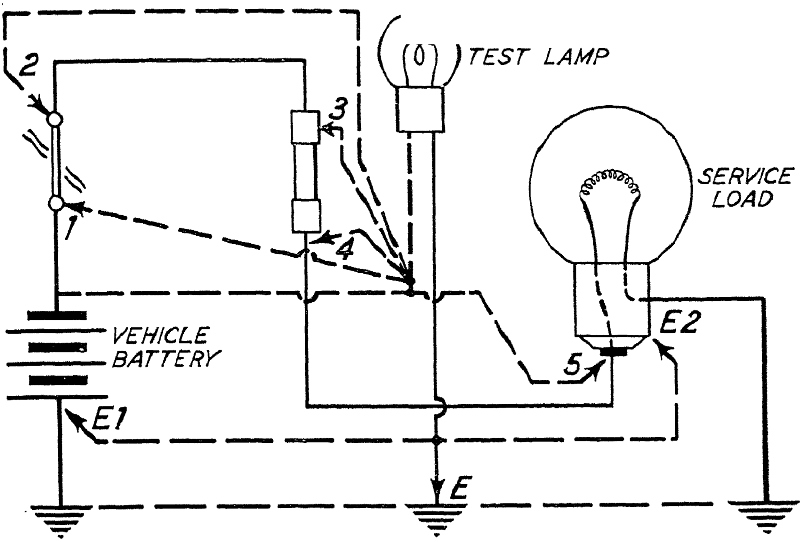


Fig. 5.—TESTING FOR OPEN CIRCUIT

connection at the switch clears the fault we know that the cable is sound.

With the switch open, continuation of reading when cable is reconnected indicates either switch terminal insulation to earth faulty, or formation of a track between switch terminals by-passing normal contacts. No further investigation is needed, as a sound switch bars the way to shorts in subsequent wiring or the unit. In the case of No. 5, we have the switch arranged in the dead line of the circuit—such as in horn circuits. Investigation here as far as, and including, the unit will reveal the cause. It cannot exist in the section from unit to switch, as a short to earth in this section would only carry the normal unit current and by-pass the switch. Current would be insufficient to blow the fuse, and the fault would manifest itself instead by the continuous operation of the unit, irrespective of switch position.

The second method of testing employs exactly the same procedure except that an abnormal load is imposed on insulation by applying a higher voltage. Magneto-type insulation testers are safer and more effective than a mains-voltage test lamp. The meter incorporated in the tester reads resistance, with infinity at the zero position. This method is especially useful for locating high-resistance shorts causing continuous battery discharge as referred to earlier. The higher voltage makes the test more searching, and intermittent or uncertain weaknesses break down under the strain, and the faults remain "on" long enough for their location to be traced.

Locating Open Circuits

Turning to the location of open circuits, we apply the same methods of normal and supernormal loading, but in this case we are dealing with current-carrying ability, or conductivity, rather than with insulation.

A complete break in a circuit disables the whole section affected, wherever its locality. The standard battery is used, and a voltmeter or test lamp enables its position to be found.

Fig. 5 shows a battery, switch, and lamp in series, the switch closed, but the service lamp inoperative due to an open circuit. The test lamp is shown connected to successive points, which, if taken in order, cannot fail to locate the fault. One lead from the test lamp is connected to common "earth" and the other applied first to point (1), when, if the lamp lights, we have established continuity of circuit from this point back to earth (E). The search is continued by testing in order at points (2) including switch, (3) cable from switch to fuse, (4) fuse, and (5) cable from fuse to lamp.

Each point at which the lamp lights exonerates the preceding section, and the first point at which the lamp fails to light indicates that the seat of trouble has been passed between that point and the preceding one. Thus if (3) is alive but (4) is dead, the fuse section (fuse, connections, or clips, etc.) is open.

Testing for Faulty Earth Section

In practice, of course, time is saved by concentrating on weakest sections most likely to be at fault. The fuse and lamp bulb would be examined and tested first, and if these are in order and the search so far fails to locate the open circuit, we still have the earthed section of the circuit which may be at fault. To test this, the test-lamp lead is left connected at point (1) and the "earthed" lead is connected to E1, when, if the test lamp now lights, it indicates open contact between battery and frame. Similarly, if there is no light with test lamp E lead connected to E2, but light shows when the E lead is connected to frame, we have an "open" between lamp cap and frame. The relationship between normal current carried by the circuit and that required by the test lamp is important, this being the reason why a voltmeter is of little use in this particular test, as its current is so small that a faulty contact, as distinct from complete O/C (open circuit), would not show up. The test lamp should be a working load equal to normal or preferably a heavier load, up to fuse capacity, when a high-resistance contact will reveal itself by local heating and subnormal brilliance of test-lamp illumination. It must be clearly understood that adequate load is essential, as a mere indication of continuity, instead of conductivity, is of no practical value.

Repairing Faulty Sections of Wiring

The following practical hints on repairing faulty sections of wiring may be successfully applied on any system, and are intended mainly for

use on sections in which the damage causing the fault is not sufficient to justify replacement of the section as a unit, which might involve a great deal of incidental labour, this being reckoned as a part of the total cost of replacement.

Fig. 6 shows a typical wiring layout using a three-rate three-brush dynamo, CFR2 Lucas control box, P.L.C. panel switch and panel assembly, dipping reflector headlamps, starter with solenoid switch, yoke mounted, and the usual auxiliary circuits of horn, screenwiper, and traffic signals. The units are shown only in outline as we are mainly concerned with the wiring.

It will be seen that the majority of the wiring is contained in a complex "loom" or "harness" of braiding woven round the bunched cables and consisting of a main trunk comprising the panel—control-box—chassis-line group, branching off forward to front lamps and horn, rearward to signals, roof lamp, tank unit, and rear lamp assembly, and across the bulkhead to ignition coil, dipswitch, and starter. Rubber-sleeve plug connectors are fitted in cables to lamps and connections to section enclosed in body panelling, while separate starter cables, panel inter-unit wiring, and body-line wiring is fitted. A separate cable also feeds the screenwiper. This method of construction facilitates assembly and is now commonly used, varying with individual makes.

Obviously, we cannot strip out and replace a whole section containing a fault, and it is necessary to locate and repair, or alternatively renew, the cables affected. Some parts of the loom are easily inspected and well placed out of the way of water saturation, oil, or mechanical abrasion, while other sections are inaccessible or exposed to these elements. These demand our first attention, and the development of a keen eye for sharp-edged, badly-fitted clips, abrasion by moving parts, exposed wires, etc., is of immense value. The plug connectors are useful in isolating sections for individual tests, but they should be suspected where O/C is the trouble, as water may enter and set up corrosion.

Typical Heavy Short-circuit Location and Repair

The following examples are two typical jobs involving wiring break-down, with test methods employed and repairs carried out, the system being that illustrated in Fig. 6.

A heavy short-circuit is noticed when the battery is connected. Test procedure followed: connect 60-watt 12-volt lamp, in holder with heavy flex leads, in series with battery and detached starter cable and place where light is visible from both sides of car. Note if ammeter reads 5 amps. discharge, with all switches off. Ammeter reads, therefore fault is on A terminal line, and starter, solenoid switch, and main cable to ammeter are clear. Check by disconnecting A wire from ammeter, when light should go out. Reconnect wire at ammeter and disconnect A wire at control box. Light remains on, therefore fault is in section from

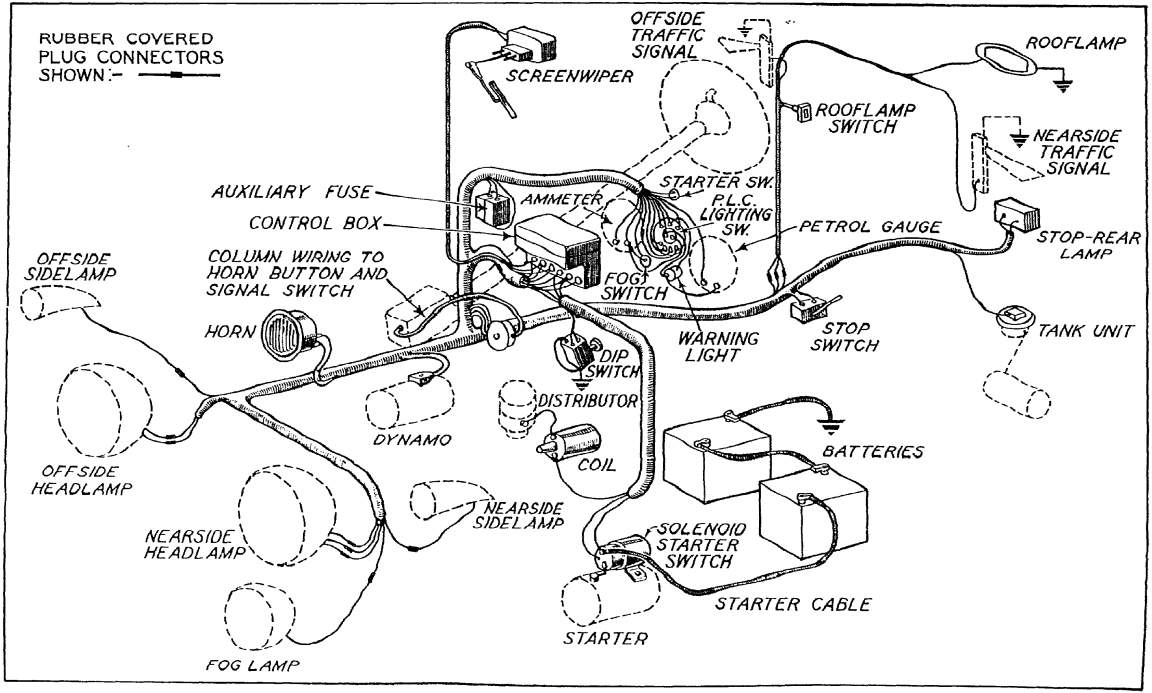


Fig. 6.—A TYPICAL CAR WIRING LAYOUT

With three-rate three-brush dynamo, CFR2 Lucas control box, P.L.C. panel switch and panel assembly, dipping reflector head-lamps, starter and solenoid switch, and the usual auxiliary circuits of horn, screenwiper, and traffic signals.

ammeter to control box. Inspection of loom under scuttle and manipulation causes light to flicker and sparks to be seen. Fault located in sharp edge of panel bracket cutting through insulation and contacting wire. Repairs effected by opening braid, taping damaged cable, taping loom and securing by strip-metal clip round loom, clip being fastened to bracket with screw.

Another Example of Fault-finding

Another example of fault-finding is given as follows: an auxiliary fuse in the control box is found to be melted when the driver reports failure of the horn. This is a typical case where effects can be misleading, as several circuits are fed by this fuse, the failure of which is discovered when the horn becomes inoperative but is not necessarily caused thereby. Test lamp connected across fuse clips is used to check circuits connected and to narrow down field of possible locations. Separate auxiliary fuse not affected, therefore lines fed via ignition switch are not concerned. Lamp lights when horn, screenwiper, "stop"-lamp, and roof-lamp switches closed: no light with switches open, therefore fault is on "dead" side of switches. Normal current of horn approx. 3–5 amps. and of screenwiper approx. 2 amps., therefore, using 12-volt 6-watt test lamp, normal illumination practically unaffected. With roof-lamp on, both this and test-lamp at about half normal illumination, indicating lamps in series and no short. With brake applied, test-lamp illumination about normal. Inspection of "stop"-lamp bulb shows this to be 12-volt 6-watt also. Inference is that short on "stop"-switch to "stop"-lamp section is by-passing current from test lamp to earth. Verified by noting that "stop"-lamp does not light with brake on and test lamp lighted. Examination of this section reveals fault in cable pinched under chassis clip, earthing both stop- and rear-lamp wires. Repaired by separately taping cables and enclosing in empire tubing, refitting clip to avoid chance of recurrence.

The reader will see that had lights been in use a general short on side-rear would have also been revealed. This would confine investigations to areas where lighting and auxiliary cables run together and we should immediately suspect the "stop"-rear section.

Intermittent Open Circuit

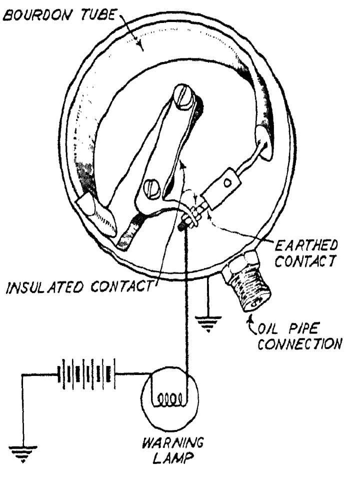
Thus we see that logical reasoning saves much unnecessary work. If the lamps flicker, all being affected, and no excess ammeter reading indicates a short, for example, we waste time if individual cables are stripped. Obviously the fault is an intermittent O/C in the common feed and can only exist in the section from the battery to the lighting switch—not forgetting the battery earth connection. It is unlikely that the same fault would exist on each lamp line and as all are equally affected, we can verify by a test lamp at the common live terminal of the switch, when this will also flicker, proving that the cause lies in the section mentioned.

OIL-PRESSURE INDICATORS

A FAILURE of the oil pressure would cause damage if the engine were allowed to continue to run. On most cars, the oil pressure is indicated by means of an oil-pressure gauge mounted on the dashboard. The disadvantage of this is that the pressure may fail without the driver being aware of this until his sense of smell warns him to look at the gauge. In the meantime, much damage may have occurred which would not have happened if his attention had been attracted earlier. To avoid this trouble, a device is fitted on some cars which causes a warning lamp to light when the oil pressure drops below a certain minimum.

To operate this lamp, an oil-pressure switch is fitted in the oil pipe. The internal construction of the switch is similar to that of the pressure gauge, that is, the pressure is imposed in a flattened-out metal tube. This flat tube is bent round in a circle, and the pressure applied tends to straighten out the tube. This straightening movement is utilised to operate a pair of contacts, which are connected in series with the warning lamp. On first switching the ignition on, the warning lamp lights because the two contacts are together. When the engine is started, the building up of the oil pressure causes the tube to slightly straighten out, which separates the two contacts. Whenever the oil pressure drops below a fixed value, say 5 lb. per square inch, the two contacts come together and the warning light is lit. This will immediately attract the driver's attention, and he can attend at once to any adjustments that may be needed before damage is done.

There is no end to the uses that this switch can be put to. For instance, the switch can be so arranged and connected that a failure of the oil pressure will open the ignition circuit. Naturally, when the engine is stationary, there is no oil pressure, and therefore a push-button is connected across the two contacts so that the ignition circuit can be temporarily closed until the oil pressure is sufficient to keep the circuit closed.



OIL-PRESSURE SWITCH

The warning lamp lights when oil pressure fails.

DIRECTION INDICATORS

THEIR CONSTRUCTION AND OPERATION

By JOHN L. P. PINKNEY, M.S.A.E.E.

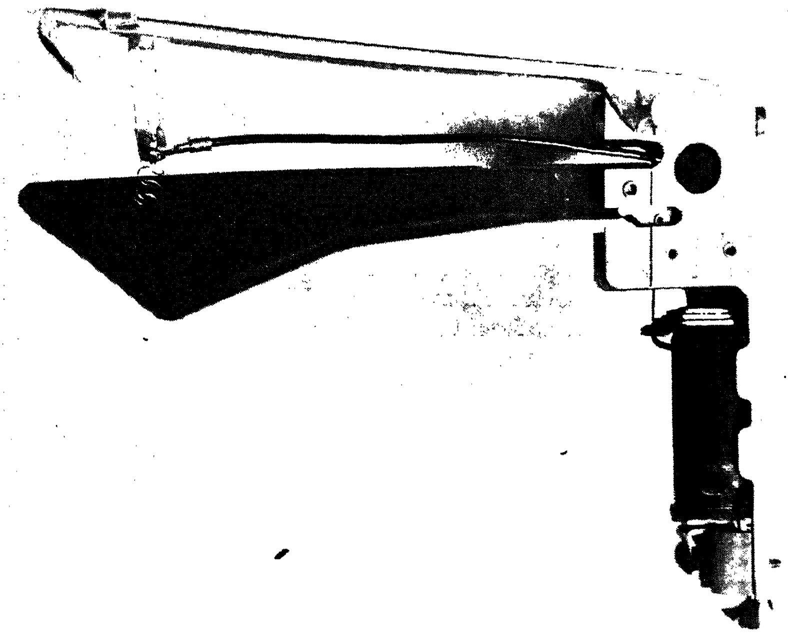


Fig. 1.—THE SKELETON FORM OF TRAFFICATOR WITH THE LAMP REMOVED

The top metal strip forms the earth connection to one end of the lamp filament, whilst the other end of the filament is connected to the short length of flexible wire by means of a round clip. The spring which is attached to the bottom of the clip ensures a good earth connection to the top of the lamp by maintaining an upward pressure. The trafficator shown is the latest pattern, with two internal switches.

PRACTICALLY all cars are now fitted with trafficators, so that a knowledge of their working is essential to all automobile repairers.

Types in Use

There are two types of trafficators in use, namely, the box or enclosed type and the skeleton type. The box type is mainly for use on goods

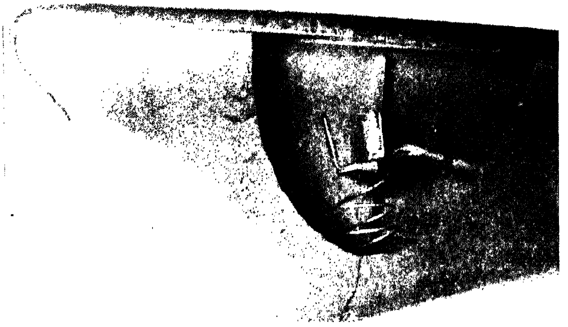


Fig. 2.—END OF THE TRAFFICATOR ARM

Part of the moulded window material has been broken away to show the position of the tubular lamp holder, its connection, and the pressure spring which forces the lamp up to the top of the arm so that this end of the lamp is in good connection with the earthed metal.

vehicles where no provision is provided to allow of recessing the trafficator into the coachwork. This type is also useful for fitting on cars having no width or depth suitable for cutting away to fit the skeleton type. All new cars turned out by the makers have the skeleton-type trafficator fitted flush with the coachwork, as this makes a much neater job.

Both types work on the same principle, that is, a signal arm is lifted up to the horizontal position by means of a soft-iron plunger drawn into the core space of a solenoid winding.

Construction of Signal Arm

The signal arm is made light so that it can be operated by a compact size of winding. If a heavier arm were fitted, it would be necessary to provide a larger winding to take a much greater current ; this would make the trafficator larger and then difficulty might be experienced in finding

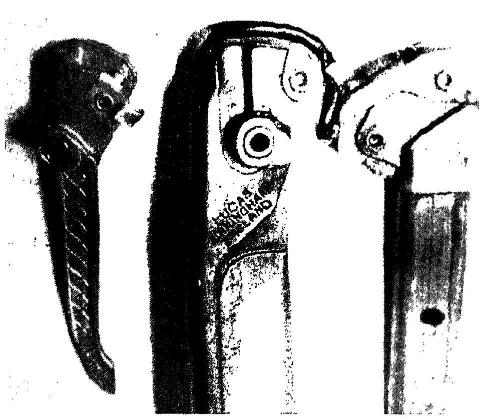


Fig. 3. PARTS OF TRAFFICATOR

The first figure is of the extended portion of the trafficator arm with the pivot hole and an anchoring clip for the flexible wire. The lower half is serrated to obtain a secure hold in the moulded arm.

The second figure is the completed top of the arm with the extended portion moulded in. The flexible wire can also be seen secured to the anchoring clip.

The third figure is of the iron plunger which is oval in shape. The top part is the linkage for the extended portion of the arm.

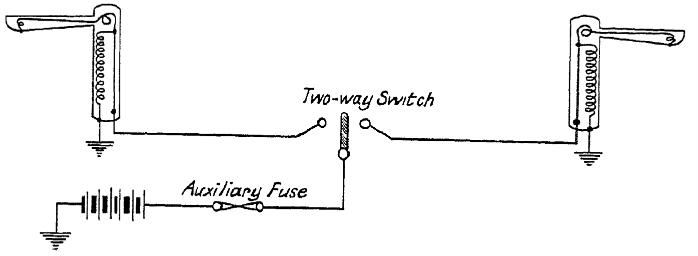


Fig. 4.—THE SIMPLEST TRAFFICATOR CIRCUIT

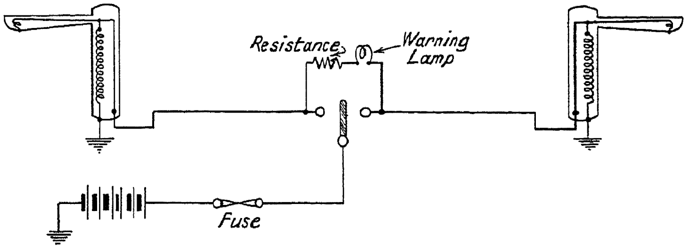


Fig. 5.—TRAFFICATOR CIRCUIT WITH A WARNING LAMP

This lamp lights via the solenoid winding of the inoperative trafficator. The lamp does not indicate whether the arm is up or whether the trafficator lamp is lit, it simply notifies the driver that the switch is in an operating position.

space for it to fit in. Although the arm is made light, it must be strong enough to resist wind pressure, especially when travelling at speed with the arm inadvertently left out. Previously, the arm was a light framework of metal with thin amber-coloured celluloid material on each side forming the windows. Much trouble was experienced with this construction, since if the arm was inadvertently left in the " up " position for long periods, the heat developed by the lamp distorted the window material, with the result that when the arm was dropped it would not go fully back into position, but would jam.

Improved Construction

The later type has a single moulding of orange-coloured material of special shape and heavier gauge almost forming the entire arm, with a reinforcing rib of metal round the top outer edge.

The Lifting Action

A die casting moulded in the arm is extended to form the hinged portion of the arm. Through a hole in this portion is a pivot pin which allows

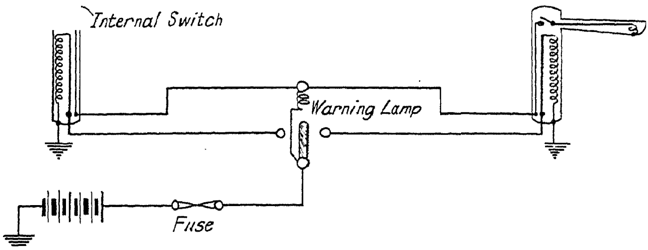


Fig. 6.—TRAFFICATOR WARNING LAMP CIRCUIT

This is a much better system, since the lamp lights when the trafficator lamp lights. When in operation, the warning lamp is in series with the "switched on" trafficator lamp. To use the circuit, the trafficator must have an internal switch for the lamp instead of the usual wire connection. Under these conditions, warning is given not only when the trafficator lamp is lit but also when the arm has lifted, since the switch does not make contact until the arm has nearly reached its upward position.

the arm to swivel up and down. The solenoid plunger is not permanently fixed to this extended portion but is linked to it. This action is essential, as the extended portion moves in an arc, whereas the plunger has a straight up-and-down motion. Furthermore, this arrangement semi-locks the arm in the "down" position so as to prevent wind pressure from blowing the arm into the "up" position, and so giving false signals to other drivers.

Working of Trafficator

When current is switched on to the solenoid winding, the resulting magnetism surrounding this winding pulls down the soft-iron plunger. Since the top of the plunger is linked with the extended portion of the arm, this portion is also pulled down and the arm is lifted up.

The Lamp Circuit

On most types the lamp, which is situated on the outermost end and inside of the arm, is connected in parallel with the solenoid winding, so that when this is energised the lamp lights. On other models the lamp is in series with a warning lamp, so that if this lamp lights, it indicates that the trafficator lamp is also lit. Unfortunately, this indication does not certify that the arm has lifted, since with the arm sticking, both lamps would still light. To overcome this difficulty, the new model has a switch integral with the trafficator arm, and the warning lamp, instead of being in series with the trafficator lamp, is in an independent circuit. This lamp does not indicate when the trafficator lamp is lit but, what is of more importance, it does indicate when the arm has lifted, since the switch does not come into operation until the arm has practically reached its upward position.

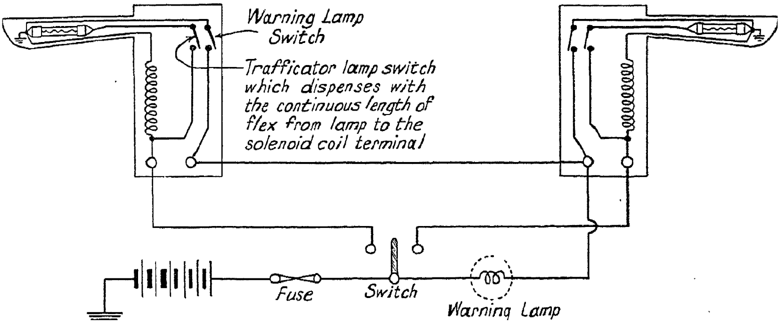


Fig. 7.—A LATER OF TRAFFICATOR, WHICH HAS TWO SWITCHES OPERATED BY THE TRAFFICATOR ARM

The warning lamp lights only when the arm has lifted and operated the internal switch. The other switch serves as a connecting link between the trafficator arm and the solenoid terminal. The warning lamp does not indicate when the trafficator lamp lights.

Lamp Wiring

Previously, the trafficator lamp was connected in circuit by means of a short length of flexible wire, but since this wire was connected to both a fixed and a moving part of the trafficator, much trouble was experienced by the fraying and the breaking of the wire, which either caused an open circuit to the lamp or created an earth. This trouble has recently been eliminated by providing a switch in the trafficator, so that the lamp wire is now fixed in position and the movement is taken by the switch arm.

Operating Switch

The first method of operating the trafficators was obviously by means of a two-way switch. This arrangement is still used, but with added refinements such as a warning lamp fitted in the switch. The switch is generally fitted in the centre of the steering wheel as being the most convenient position for the driver to operate it.

Self-cancelling Switches

The drawback to the hand-operated switch is that, due to forgetfulness on the part of the driver, the trafficator arm is often left in the "up" position, thus causing uncertainty of action to other drivers. To counteract such action, a semi-automatic switch is fitted to the top of the steering wheel so that on the completion of the turn of the car, the action of returning the wheel on to the straight again automatically switches off the trafficator. Although the switching-off motion is automatic, the switch can also be hand operated if so desired.

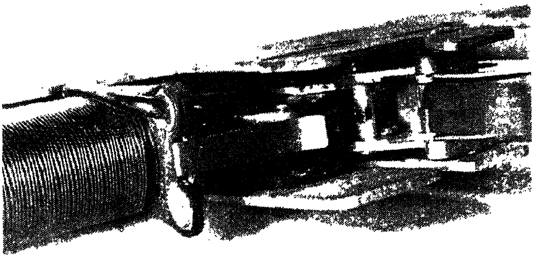


Fig. 8.—UNDERNEATH SIDE OF TRAFFICATOR ARM

Showing the extra switch contact which operates the warning lamp when the arm has lifted. When the plunger is drawn into the solenoid coil, the top of the plunger comes into contact with the switch contact strip, which is then earthed. This completes the warning lamp circuit.

How the Switch Works

The moving part of the switch mechanism has a plate contact which shorts out the accumulator feed to either the left- or right-hand trafficator feed. There is also a toggle cage containing two spring-operated toggles mounted side by side. Also in the cage is a spring - operated plunger having a roller at its bottom end. This roller rides on the edge of a special shaped steel locking plate which is fixed to the base of the switch. As the switch is turned to either the right or left direction, the roller rides up the shaped edge of the locking plate until it reaches a depression, when the roller is locked. Also fixed to the base of the switch is a cam which operates the toggles. Mounted on the inner circumference of the steering-wheel boss is a switch-releasing plate which catches one or the other of the toggles on the return of the steering wheel to the straight. In the normal position, this releasing plate is in between the two toggles.

How the Switch is Operated

When a left-hand turn is contemplated, the switch arm is manually turned to the left to operate the left-hand side trafficator. This does not only operate the trafficator ; it also causes the cam to partly shift the right-hand side toggle, so that as the steering wheel is turned to the left this toggle misses the releasing plate. As the wheel is further turned to the left, the releasing plate passes over the left-hand side toggle, causing its spring to be compressed and then released. On the completion of the left-hand turn, the steering wheel is turned to the right to bring the car on to the straight again, and in so doing the releasing plate catches the left-hand toggle and this releases the switch to the " off " position.

Delayed-action Switch

Another type of self-cancelling switch works on the delayed action of a train of wheels. When the switch is hand operated to the " on " position, a spring is wound up and drives a train of wheels so that, after a

period of time, the switch is operated automatically to the "off" position. Although this switch does not take into account the time required to turn a corner, it is nevertheless a useful switch, as it prevents the trafficator arm from being accidentally left out.

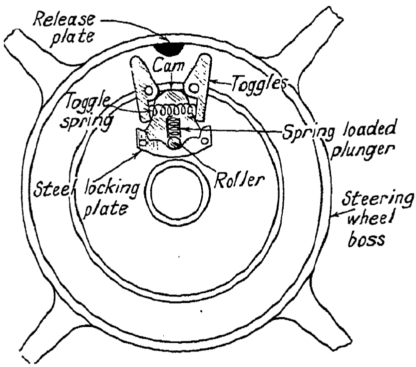


Fig. 9.—AUTOMATIC CANCELLING SWITCH

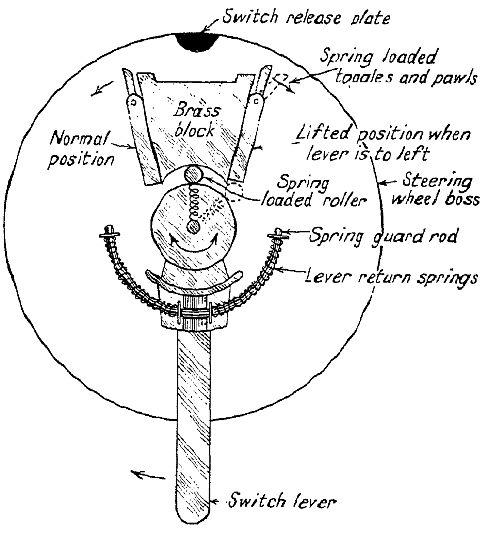
This operates the trafficator switch to the "off" position when the steering wheel is returned to the straight after cornering.

Repairing Trafficators

With the older models, one of the most common complaints is the failure of the trafficator lamp to light. This is mainly due to the breaking of the flexible wire connecting the lamp to the solenoid circuit. This wire can be replaced, but care is needed to see that there is just sufficient slack in the wire where it loops round the pivot pin. If this is not done, the arm will not work as the tightness of the wire will prevent it. Another source of trouble is the breaking of the extended portion of the arm. This is a die casting and is very easily broken. To effect a repair, the trafficator must be removed from the car and the pivot pin knocked out.

Fig. 10 (*right*).—SELF-CANCELLING TRAFFICATOR SWITCH

This shows another type of switch-release mechanism which is made part of the steering-wheel boss. The two toggles are loose and are guided by slots in moulded bakelite. When the switch lever is moved over, the spring-loaded roller rides off the brass block and lifts up the toggle, which causes the toggle pawl to be lifted up. When the steering wheel is turned, the release plate rides over the pawl and the pawl springs back again. On the return of the wheel to the straight, the release plate forces the toggle downwards, which pushes the spring-loaded roller on to the brass block, and with the help of both the slope on the brass block and the lever-return spring the switch lever is forced back to the "off" position.



A replacement arm is then fitted, since the old one will be beyond repair. After fitting the pivot pin, it must be riveted lightly over to prevent it from coming out, taking care in doing so not to break the casting.

High-resistance Earth

In two-terminal trafficators, fitted on an earth-return system, it is the general practice to take the earth connection to a suitable position on the chassis, as an earth connection on the bodywork is unreliable. If such a bodywork earth is used, it may account for the erratic operation of the trafficator, since the conductivity between the bodywork and the chassis is generally of a high resistance.

Care in Connecting

Although it is common practice not to rely on the earthing of the trafficator through the bodywork, it is nevertheless important to connect the trafficator wires to the correct terminals, as some trafficators have an internal earth connection, in which case crossed leads will cause an earth fault.

Replacing Lamps

Before replacing a faulty bulb, it is best to raise the trafficator arm by means of the switch and to hold the arm out by hand and then switch off. This practice not only lessens the chance of straining or even breaking the arm or its linkage, it also prevents causing an earth whilst removing or replacing the bulb.

The Lamp Wattage

Care must be taken when replacing bulbs to make sure that they are of the correct wattage and voltage. This also applies to the warning lamps, especially if these are in series with the trafficator lamp.

Sluggish Action

When the movement of the arm is sluggish or uncertain, it may be caused by grit gaining access to the moving parts or by rusting of the solenoid plunger. It is well worth while to slightly smear a very thin grade of oil on to the plunger to prevent rusting, but do not overdo this or else the oil will gather dust and dirt which will aggravate the trouble.

Sticking Arm

A trafficator arm which does not go right back can be due to a strained arm or to an obstruction in the housing, such as a connecting wire with too much slack. Worn pivot pins and a worn linkage will also account for the arm sticking. To prevent wear on the moving parts, they can be oiled with a light grade of oil such as sewing-machine oil, but even this must be sparingly done.

PETROL AND OIL GAUGES

By JOHN L. P. PINKNEY, M.S.A.E.E.

IT is a great convenience to be able to tell at a glance the amount of petrol there is in the tank, or whether there is enough oil in the sump. Previously, this information was arrived at by looking into the tank or by calculating the number of miles travelled since the tank was last filled. This method did not take into account hill climbing, low-gear running, wrong setting of the carburettor, and the numerous stoppings and startings, each of which consumes more petrol than the long steady pace at the engine's economic speed.

To confirm the amount of oil in the engine sump was a messy job and was done by the crude method of a dipstick and, for this reason, seldom done.

Mechanical Indications

One method of indicating the level of the petrol in the tank was by means of a long sighting glass fixed on the dashboard, but that was in the days when the tank was fixed behind the dashboard. Another method was by means of a float in the tank. A dial, graduated in gallons, was fitted in the cap of the tank. The pointer on the dial was controlled by the height of the float, the motion of which was converted to a rotary motion. Even this system was inconvenient, as in most cases it meant getting out of the car to examine the gauge.

ELECTRICAL INDICATORS

One of the electrical methods at present used for indicating the amount of petrol in the tank is the Hobson Telegage dealt with on pp. 55–64. A further method is by utilising a variable resistance and sometimes a potentiometer in conjunction with a voltmeter. These indicators show approximate amounts, because it is economically impossible to have a device indicating the exact quantity of petrol due to the fact that the petrol is on the move all the time the car is travelling.

Their Construction

The system makes use of three main parts, namely, the *float*, hinged to a cast-metal case, which can be screwed to the top of the tank. The hinge allows the float to rise and fall with the height of the petrol in the tank. These rise-and-fall movements are transmitted to a wiper

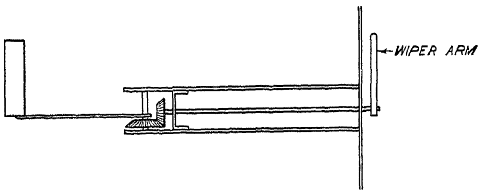


Fig. 1.—THIS SHOWS THE OLDER METHOD OF TRANSFERRING THE UP-AND-DOWN MOVEMENTS TO THE ROTARY MOVEMENT OF THE WIPER ARM

arm which wipes over the surface of a *resistance* winding situated inside the metal case.

Older Models

Previously, two bevel wheels were used to convert the up-and-down movements to a rotary movement for the working of the wiper arm across a circular-shaped resistance, and it was often found that these two bevel wheels locked together, preventing the proper working of the unit.

Recent Models

Recent models do not have these bevel wheels, and this has made the unit much simpler and less liable to introduce errors caused by friction of the moving parts. Whereas the older models had a circular-shaped resistance necessitating a rotary motion of the wiper arm, the new type has a flat strip resistance, which needs only a simple sliding action of the wiper arm. This sliding action is transmitted direct from the float to the spindle carrying the wiper arm and so dispenses with intermediate transmission.

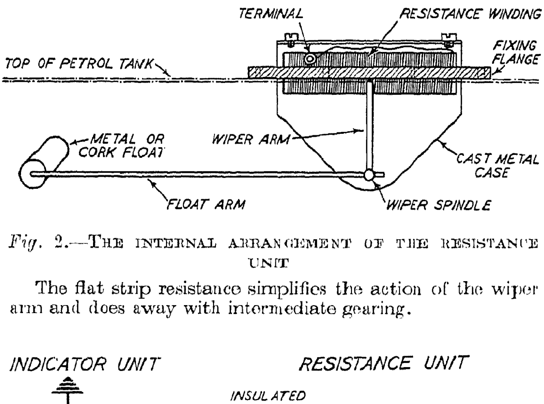


Fig. 2.—THE INTERNAL ARRANGEMENT OF THE RESISTANCE UNIT

The flat strip resistance simplifies the action of the wiper arm and does away with intermediate gearing.

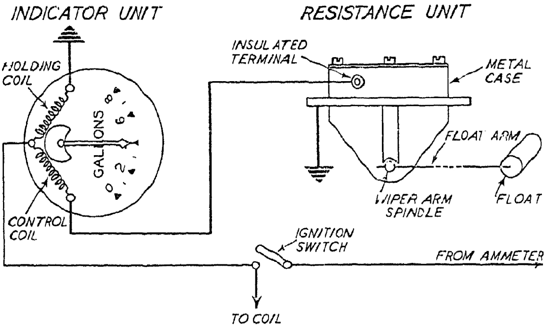


Fig. 3.—PETROL GAUGE SHOWING THE MORE USUAL METHOD OF CONNECTIONS

The Gauge

The indicating device is really a

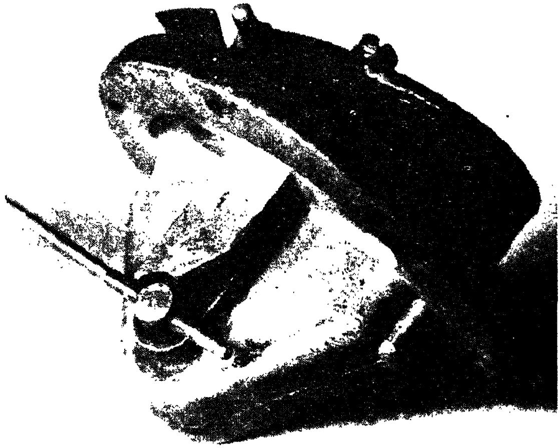


Fig. 4 (right).—P GAUGE RESISTANCE UNIT

An enlarged view of the resistance unit. Part of the float arm can be seen. This arm is a tight fit through a hole in the wiper arm spindle. At the top, left, can be seen the main terminal, which is further protected from the casting by a strip of insulation.

differentially wound galvanometer possessing two separately wound coils of fine, insulated, copper wire. These two coils are fixed at right angles to each other and they each provide their own magnetic field. Both these coils act magnetically upon the armature, which is pivoted and floats in the centre of the coils. To this armature is fitted the pointer, which indicates on a dial marked off in gallons or is calibrated from "full" to "empty" with intermediate quarters.

Voltage Variation

On the face of it a simple variable resistance in series with a voltmeter, with the scale calibrated in gallons, should be adequate, but this is not so, since the voltage of the battery or accumulator would to a great extent control the readings on the gauge. It is well known that the voltage of the accumulator varies a great deal with

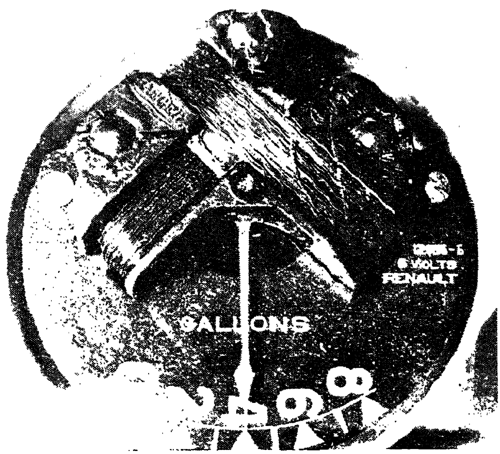


Fig. 5 (right).—PETROL GAUGE

This shows a close-up view of the differentially wound indicator with the scale marked off in gallons. A close inspection will show that this is a faulty unit, since there are a number of broken turns of wire in one of the coils.

the load imposed upon it, and this alone would render misleading the indications on the meter.

The present arrangement of having two coils incorporated in the gauge makes the indications independent of these variations in the accumulator voltage.

How the Gauge Works

One of the coils is connected across the accumulator, and the strength of the magnetic field around this coil is governed by the voltage of the accumulator. This coil acts as a holding coil and it has a tendency to pull the pointer of the gauge to the "empty" mark. It also prevents the pointer from floating about all over the dial, since the movement is not spring-controlled in any way. The other coil is also connected across the accumulator, but in this case it has the resistance unit in series with it, so that the strength of the magnetic field of this, the control coil, is governed not only by the voltage of the accumulator but also by the amount of resistance there is in series with it. It will now be understood that any variation in the accumulator voltage, which would otherwise upset the dial reading, will be cancelled out by the two opposing coils.

With the Tank Empty

When the tank is empty, the float will be down and the resistance-wiper arm will be at the extreme end of the resistance winding, thus leaving all of the resistance in series with the control coil of the gauge. This will weaken the magnetic field around this coil to such an extent as to leave the "holding" coil full control over the position of the pointer, and so the pointer is forced over to the left or "empty" side of the dial.

With the Tank Full

With the tank full of petrol, the float will be up and the resistance-wiper arm will be forced along to the other end of the resistance winding. This will cut out the resistance between the control coil and the accumulator, so that the strength of the magnetic field around this coil will be increased sufficiently to take over the control of the pointer, so that it will indicate a full tank.

Oil Gauge

On some cars, the gauge also indicates the amount of oil in the sump. As there is no advantage in being able to verify the level of both the petrol and the oil at the same moment, the one gauge does duty for both purposes. To indicate the oil level, there is a resistance unit and a float in the oil sump. Mounted on the dashboard is a change-over switch, so that one or the other resistance unit can be placed in circuit with the

Servicing of Petrol Gauge

The three most common faults occurring with these petrol gauges are broken resistance winding in the tank unit, burnt-out coils in the indicating unit, and bad contact between the wiper arm and the resistance winding. In the case of the first two mentioned faults, the only practical proposition is to replace the faulty units. A bad contact between the wiper arm and the resistance winding can be remedied by slightly bending the wiper arm so that it presses more firmly on to the winding.

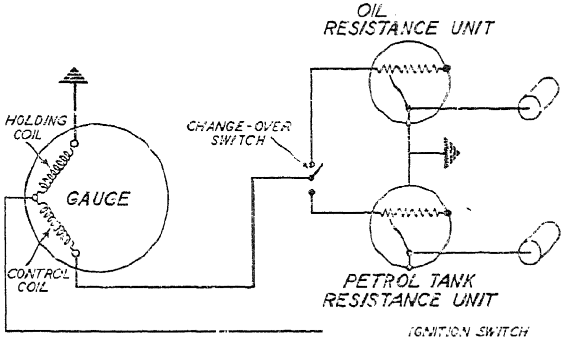


Fig. 6.—COMBINED PETROL AND OIL GAUGE UTILISING ONE INDICATING UNIT

Care to be Taken

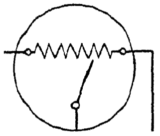
When the tank unit is being removed, care must be taken not to bend the float arm, otherwise, when it is replaced, it will cause false readings to show on the gauge.

Indications of Faults

When the ignition is switched on and the gauge pointer does not move, it indicates that no current is reaching the coil windings. This fault can therefore be due to either a broken connection between the ignition switch and the gauge, or the two gauge coils open-circuited. When the pointer indicates "empty" all the time, it is probably due to either a sticking float, a break in the resistance winding, or a burnt-out control coil. But with the pointer on the "full" mark all the time, the break in the circuit will be in the holding coil, or else the float is sticking in the "up" position.

Low Reading on Gauge

One reason for a low reading showing on the gauge is a heavy float. There are two types of float in use, one being the usual sealed metal container, the other type being made of cork, suitably protected by a covering of petrol-proof varnish to prevent it being soaked with petrol. In the metal type, the slightest hole will allow petrol to seep through and this will cause the float to become too heavy. Damage to the protective coating on the cork float will allow the cork to become saturated with petrol, causing the float to have more weight.



Mode of Connection

These fault positions refer mainly to gauges connected up as in Fig. 3. This should be made clear, since there are various methods of connecting up, as will be seen in the other diagram, Fig. 7. For instance, when the "holding coil" and the "control" coil are on the opposite sides to those shown in Fig. 3, the faults, showing the pointer at "full" or "empty" as the case may be, will be the reverse of those given above.

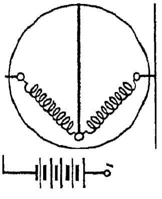


Fig. 7. (*left*)—THIS SHOWS ONE ARRANGEMENT OF CONNECTIONS UTILISING A POTENTIOMETER

Both coils of the gauge are across the battery tending to force the pointer to the centre of the dial. The position of the wiper arm determines which coil is the control coil.

TESTING AND REPAIRING THE A.C. FUEL PUMP

By J. N. QUEENBOROUGH

LIKE many of the specialised components which are doing such an excellent job of work on modern cars, the A.C. fuel pump has steadily evolved from its original form, with the result that, to-day, any one of five separate models may be encountered by the serviceman. It is a tribute to the initial design, however, and a source of satisfaction to garagists, that the operating principle is the same now as it was when the pump was introduced, the differences between the models being of detail only.

Figs. 1 and 2 are sectional diagrams of the latest model—Series T—

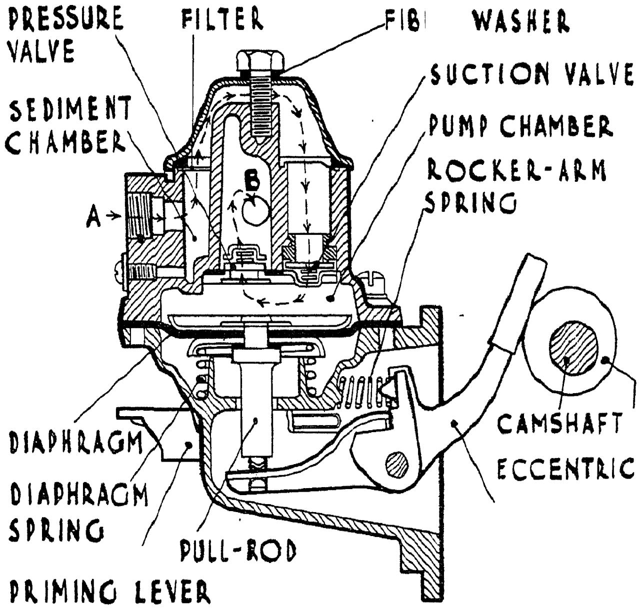


Fig. 1.—Sectional diagram of the latest A.C. fuel pump, series T.

The arrows indicate the path of the fuel through the pump on its way from the tank to the carburettor.

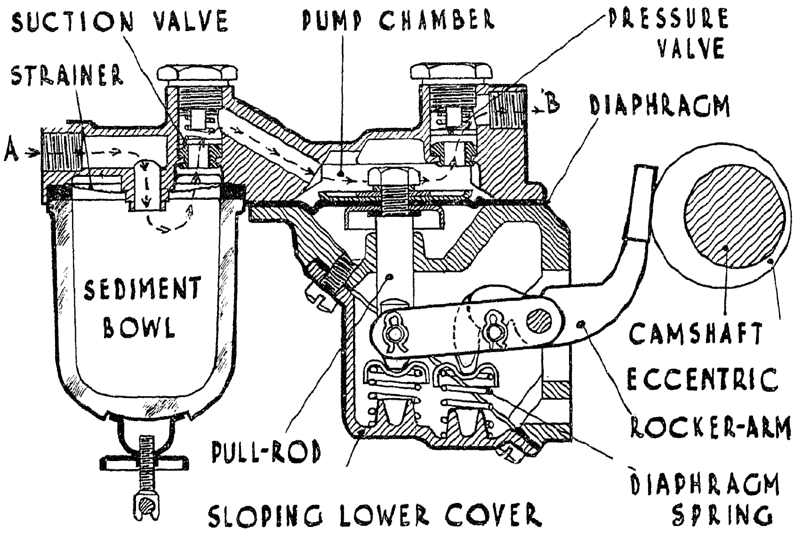


Fig. 2.—SECTIONAL DIAGRAM OF AN EARLY A.C. FUEL PUMP, SERIES B

The arrows indicate the path of the fuel through the pump on its way from the tank to the carburettor.

and one of the early models—Series B—respectively, and although at first glance they appear to differ widely, examination will quickly reveal that the contrary is the case.

On both models rotation of the eccentric on the camshaft lifts the rocker arm, the other end of which, being attached to the diaphragm by a pull-rod, pulls down the diaphragm and creates a vacuum in the pump chamber.

Formation of the vacuum causes fuel to leave the car tank and enter the pump at *A*, from whence it proceeds, via the sediment chamber, the filter, and suction valve, into the pump chamber. On the return stroke, pressure from the diaphragm spring forces the diaphragm upwards, thus ejecting the fuel from the pump chamber, through the pressure valve, and opening *B* into the carburettor.

On the carburettor bowl becoming filled, the float shuts off the inlet needle valve, thereby creating a pressure in the chamber of the pump, and this pressure holds the diaphragm down against its spring until the carburettor needs more fuel and the needle valve opens.

Types of A.C. Fuel Pumps

As already stated, the operating principle just described holds good for all five models, but the models vary in design, and the way to tell one from the other is by noting the following features :

Series A.—(In general use up to about the end of 1931.) The chief outside distinguishing characteristics are a glass filter bowl and a horizontal lower body cover. The linkage is attached to an inward extension of the rocker arm, and is hinged to absorb the movement of the eccentric when fuel is not required by the carburettor.

Series B.—(Used since 1931 on cars of about 10 h.p. and upwards.) This model—illustrated in Fig. 2—also has a glass filter bowl, but the lower cover of the body is of a sloping pattern, and the rocker arm bears on a pin fitted in the linkage.

Series M.—(Used on small cars during 1932–33.) Has a sloping lower cover to the body, but has a sediment bowl incorporated in the pump itself, similar to that shown in the Series T section (Fig. 1).

Series Y.—(Used on small cars from 1933.) Has a built-in sediment bowl also, similar to the Series T, but the body is a single-piece casting, having no lower cover. An important internal difference is that the plug-type valve retaining device, used on the Series A, B, and M, is replaced by the plate-type assembly shown in Fig. 1.

Series T.—(This is the latest and most efficient type of A.C. pump.) As Fig. 1 shows, the body is a single-piece casting with no lower cover, and the sediment bowl is incorporated on top of the pump.

Instead of the long rocker-arm device, A.C. pumps are sometimes designed for push-rod method of operation.

TESTING

For rapid testing of a pump in which trouble is suspected, the A.C. people have devised an ingenious analyser which enables the operation of a pump to be checked without removing the unit from the car. Use of this analyser undoubtedly saves time, if only for revealing, perhaps, that the pump does not, after all, require servicing, for, as regular repairers of fuel pumps are well aware, inefficiency is wrongly attributed to these components with annoying frequency. (Full instructions for its use are given with every analyser, so that there is no point in describing it in detail here.)

A golden rule for mechanics who are new to fuel pump servicing is: "Don't assume that a pump is inefficient, however strong the indications, without first carefully examining all possible contributory factors." That may sound elementary, but it becomes less so with the knowledge that pumps have often been condemned by their owners for no other reason than that the petrol tank was empty.

Leaky, bent, or choked tubing and leaky connections are frequent causes of trouble—such as a lack of fuel at the carburettor, and difficulty in starting—which should be looked for before touching the pump itself. Similarly, complaints of leakage of fuel at the diaphragm can sometimes be traced to a fault in the pipe fittings, fuel having run down the pump

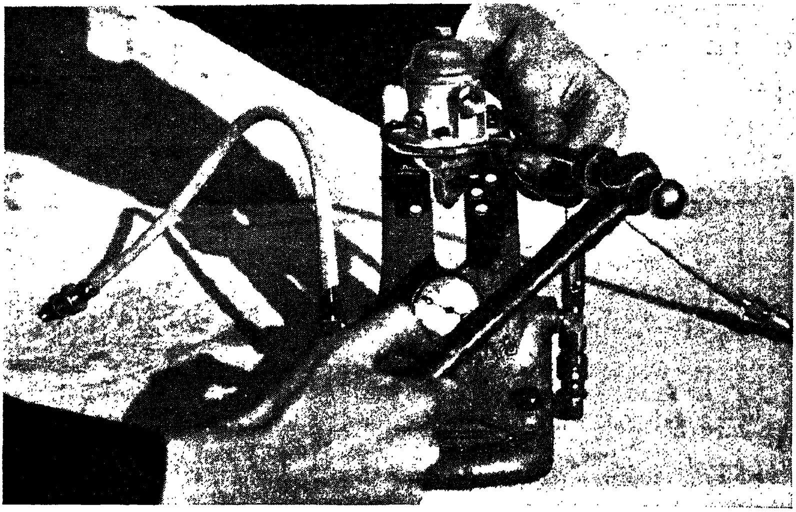


Fig. 3.—TO DISMANTLE THE PUMP (1)

Attach it to an A.C. test stand, and mark the position of the top cover relative to the body casting.

in such a manner as to appear to be coming from the diaphragm flange itself.

Vapour Lock

Another occasional non-pump cause of poor fuel delivery is vapour lock, due to some part of the pipe system being located too close to the exhaust system, the latter heating the fuel enough to make it vaporise. As a matter of fact, the pump itself can also be guilty of vaporisation if its installation is such that no cooling draught can reach it, or if it is placed too near the exhaust system. In the latter event, the trouble can be cured by fitting a small shield.

Filter Cover

If the lack of fuel persists after the tubing and connections have been checked, examine the filter cover (in the case of Series, M, Y, and T pumps). If it is loose, tighten the nut, making sure that the cork gasket fits perfectly in its seat and makes an airtight joint without being unduly compressed.

Alternatively, the filter screen itself may be dirty, in which case it should be removed and cleaned (Fig. 4).

The relative treatment for Series A and B pumps consists in examining the glass bowl to ascertain whether it is loose ; if it is, tighten the thumb

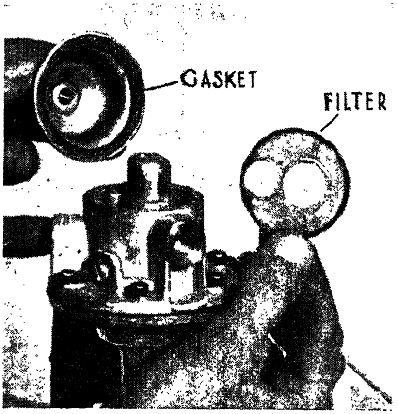


Fig. 4.—To DISMANTLE THE PUMP (2)
Take off filter cover by removing cover screw, and remove gasket and filter.

Fig. 5.—To DISMANTLE THE PUMP (3)
Detach the top casting by taking out the six fixing screws holding it to the body.

nut, here again making certain that the cork gasket lies flat in its seat. If the bowl is not loose, look for a dirty filter screen.

Leakage of Fuel at Edge of Diaphragm

Leakage of fuel at the edge of the diaphragm is a trouble which can sometimes be cured without removing the pump from the car, by checking the cover screws. If they are loose, tighten them, not consecutively but alternately (Fig. 18).

Flooding of the Carburettor

Perhaps the most outstanding malady which some car owners assume to be due to the fuel pump is flooding of the carburettor. The pump is never wholly the cause, although it can sometimes aggravate the flooding as a consequence of air getting drawn in through leaky pipe joints or the filter gasket. The normal remedy for carburettor flooding is to check the unit for adjustment, or clean out the float chamber.

Noisy Pump

If a pump is complained of as being noisy—due, presumably, to worn or broken parts—it may save trouble, before dismantling it, to run the engine minus the pump to ascertain whether the noise is not, in fact, in the engine itself. Care should be taken, of course, that oil does not escape unduly through the pump-mounting hole.

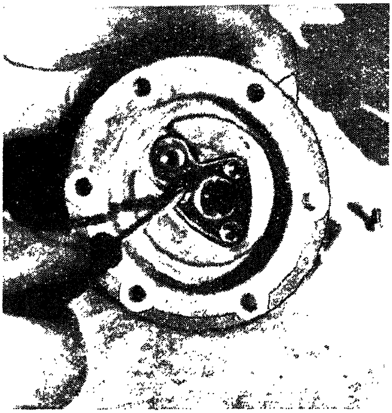


Fig. 6.—To DISMANTLE THE PUMP (4)

Remove screws holding valve retainer to top casting, take out valves, springs, and valve-spring retainer, and place all parts in clean paraffin bath.

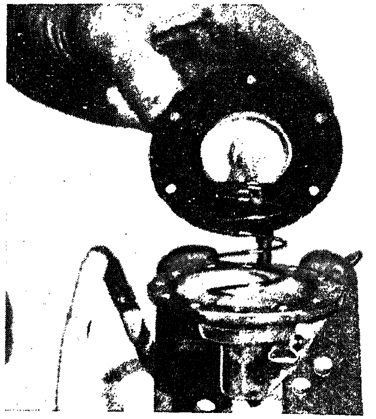


Fig. 7.—To DISMANTLE THE PUMP (5)

Detach diaphragm and pull-rod assembly from link by pressing down and giving a quarter turn.

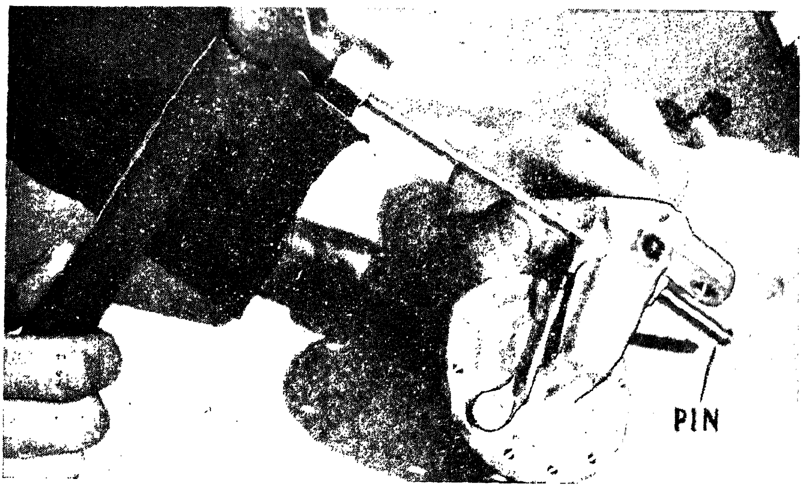


Fig. 8. To DISMANTLE THE PUMP (6)

Detach pump from test stand, take off spring clip from one end of rocker-arm pin, drive out pin by means of a driftrod. This will release rocker arm, link, rocker arm s[illegible] and (if fitted) two s[illegible] washers.

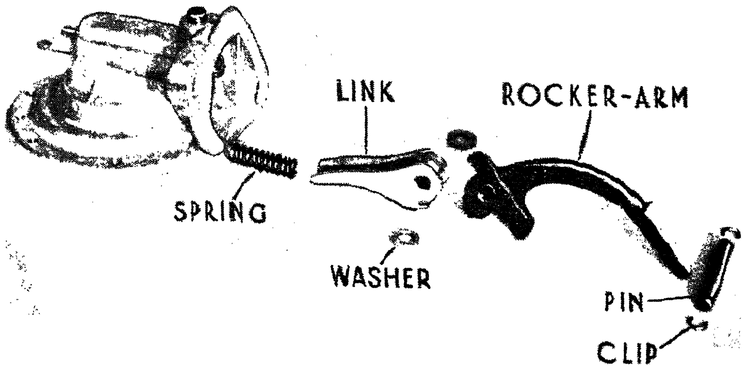


Fig. 9.—To assemble rocker arm and link assembly (1)
Gather together parts shown.

Dismantling the Pump

If none of the preliminary tests and checks described above has succeeded in locating the trouble, and it is decided that the pump must be taken to pieces for rectification, the following procedure should be followed. The pump chosen for the purpose of the illustrations is a Series T, because of its popularity, but, as a matter of fact, the instructions give a good idea of the manner in which all the pumps of the A.C. range should be handled.

Special Test Stand

It is assumed that the serviceman who undertakes the overhauling of an A.C. pump possesses the test stand specially designed for this purpose (*see* Fig. 3). The stand consists of a U-shaped apparatus which is bolted to the bench, and to the top of which the pump is attached by means of special bolts and wing-nuts supplied. The stand is connected to a reservoir containing the testing fluid, and the results of a test are shown on an easily seen gauge. (Incidentally, this test stand can be obtained from Delco-Remy and Hyatt Ltd., 111 Grosvenor Road, London, S.W.1, who are, of course, the official A.C. service organisation for Great Britain, Northern Ireland, and Eire.)

Mark the Position of the Top Cover

The pump having been attached to the stand, the position of the top cover relative to the body casting should be marked, by means of either a centre-punch or a file (Fig. 3). This is a most essential part of the

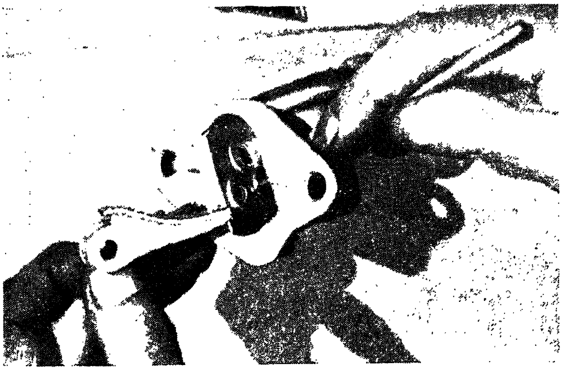


Fig. 10.—TO ASSEMBLE ROCKER ARM AND LINK ASSEMBLY (2)
Insert driftrod into one side of rocker-arm-pin hole, and put on spacing washer and link.

proceedings which, if forgotten, is almost bound to cause loss of time when reassembling.

Take off the filter cover by removing the cover screw, and remove the gasket and filter (Fig. 4). Detach the top casting by taking out the six fixing screws which secure it to the body (Fig. 5). Take out the three screws which hold the valve retainer to the top casting (Fig. 6). This will release valves, springs, and valve-spring retainer. All the parts so far disassembled should now be placed in a clean paraffin bath, which should be kept apart from the bath used for cleaning the remainder (and comparatively dirty) parts.

Remove the diaphragm and pull-rod assembly from the link by pressing down and giving a quarter-turn (Fig. 7). Detach the pump from the test stand, remove a spring clip from one end of the rocker-arm pin, and drive out the pin by means of a drift-rod (Fig. 8), which should be about five-thousandths undersize. This will release the rocker arm, link, rocker-arm spring, and (if fitted) two spacing washers.

Clean and Examine All Parts

All parts should now be thoroughly cleaned, and examined to ascertain the cause of the pump's inefficiency. Badly worn parts must, of course, be replaced, and it is best to replace all gaskets, however healthy they may appear to be.

Reassembling Rocker Arm and Link Assembly

To reassemble the rocker arm and link assembly, gather together the parts shown in Fig. 9. If the spring is distorted or broken, it should, of course, be replaced, and the same applies to the other parts. If the rocker arm has to be renewed, make sure that the correct type is fitted, otherwise insufficient or excessive movement may occur, together with, perhaps, breakage of the arm and pump body. In the case of push-rod-actuated pumps, the ends of the push-rod should be closely examined for wear, and if necessary the rod must be renewed.

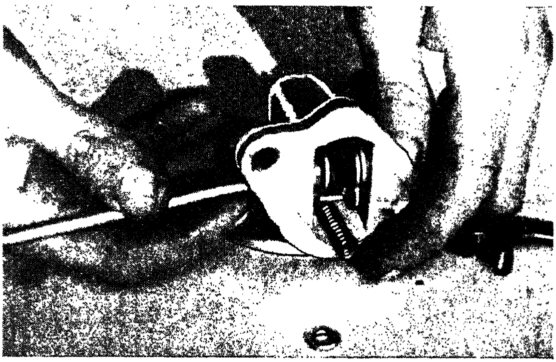


Fig. 11.—To assemble rocker arm and link assembly (3)
Place rocker-arm spring in position.

The quickest way to reassemble the rocker-arm assembly is to insert the drift-rod (previously used in breaking down the unit) into one side of the rocker-arm-pin hole, and to arrange on it first one spacing washer (if fitted) and then the link (Fig. 10). Still holding the drift-rod, place the rocker-arm spring in the position indicated in Fig. 11. Next, place the rocker arm on the drift-rod between the faces of the link (making sure that the pip on the rocker arm fits snugly into the end of the spring), place the second spacing washer (if fitted) on the drift-rod, and drive out the rod by means of the rocker-arm pin, to one end of which a retainer clip should first have been fitted (Fig. 12). When the pin is right home, be sure to snap on the second retainer clip to the other end of the pin.

Valve Assembly Parts

The order of assembly of the valve-assembly parts is illustrated in Fig. 13. Before reassembly is commenced, however, the parts must be individually examined. If the valve seats in the cover casting or valve-retainer plate are worn, do not attempt to reface them, but renew the affected parts as a whole. Unless

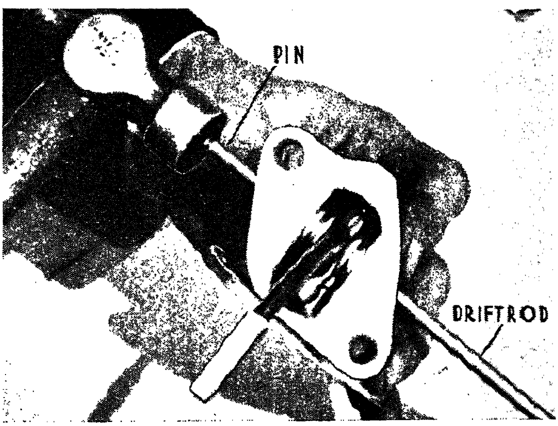


Fig. 12.—To assemble rocker arm and link assembly (4)
Place rocker arm and second spacing washer on drift-rod, and drive out the rod by means of the rocker-arm pin. Snap on retainer clips at each end of the pin.

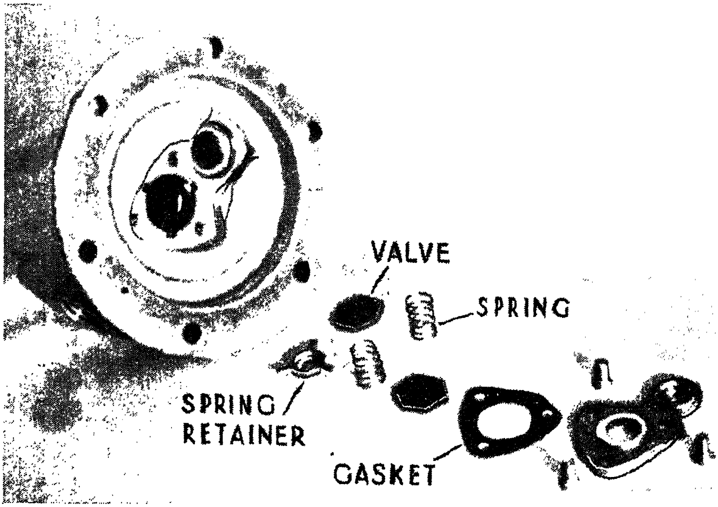
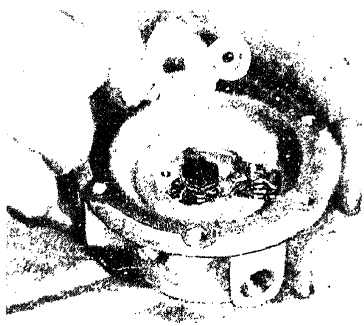


Fig. 13.—ORDER OF REPLACEMENT OF THE VALVE ASSEMBLY PARTS

they are in first-class condition, the valves should be replaced by new ones. In this connection it will be found convenient always to keep a supply of valves soaking in paraffin and ready for use, if a fair amount of pump overhauling is to be undertaken.

Fig. 14.—TO ASSEMBLE VALVE PARTS (1)

Put in spring retainer, with the cupped portion downwards, then the ings and valves.



15. TO ASSEMBLE VALVE PARTS (2)

Fit valve retainer plate, with its gasket underneath, and secure by three screws.

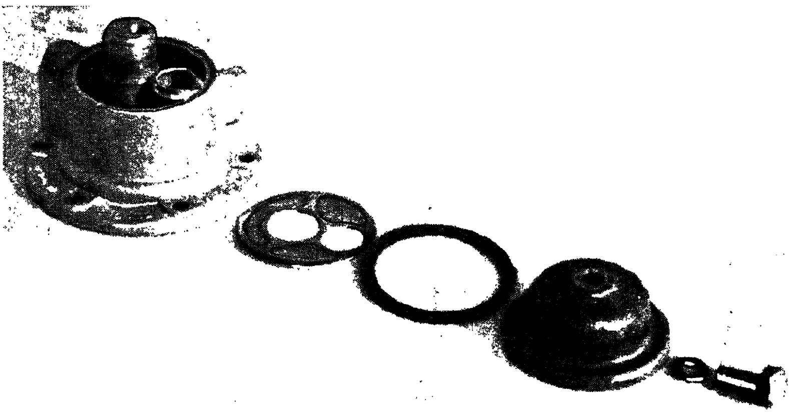


Fig. 16.—TO ASSEMBLE FILTER UNIT
Put together parts in order shown, taking care not to injure gasket.

The valve springs should also be renewed. On no account should they be stretched or altered in any way. Springs or valves which have been tampered with can easily result in difficult starting.

Assembling the valve parts is a tricky business, and requires nimble fingers and steady hands. First put in the spring retainer, with its cupped portion downwards; then one valve, with the polished face towards the valve seat; insert the springs—one in the spring retainer and the other on the valve—and balance the second valve on top of the spring in the spring retainer, with the polished face towards the valve seat (Fig. 14). Finally, fit the valve-retainer plate, making certain that the gasket is underneath, and fix by three countersunk screws (Fig. 15).

Gumminess—a Possible Cause of Valve Trouble

A very occasional valve trouble which may be mentioned here is that of gumminess, the result of impure fuel, and sometimes, to a certain extent, of upper-cylinder lubricant. If gumminess was noted when the valves were taken down, the attention of the car owner should be drawn to the fact to prevent reoccurrence of the trouble.

Filter Parts

Having completed the valve assembly, put together the filter parts in the order shown in Fig. 16, and make certain that a fibre washer is placed under the head of the cover setscrew. And when tightening this setscrew, ensure that the gasket lies flat on its seat, and is not broken or unduly compressed.

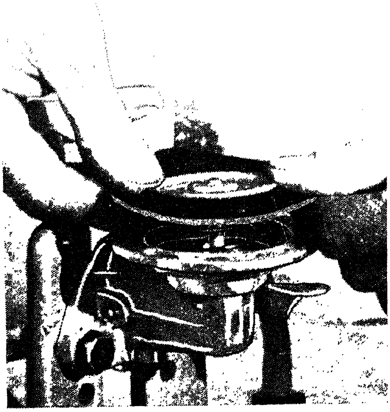


Fig. 17.—COMPLETING ASSEMBLY OF PUMP (1)

Attach body to test stand, replace diaphragm spring, and refit diaphragm and pull-rod assembly by pressing down diaphragm and giving it a quarter-turn. The final operation in assembling the pump is shown in the next illustration.

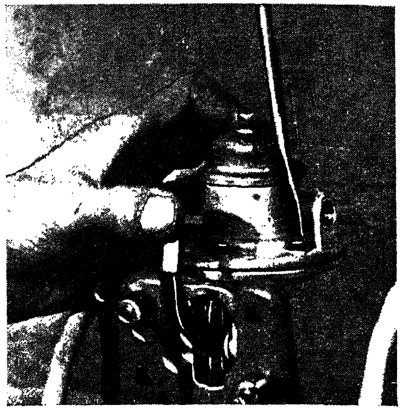


Fig. 18.—COMPLETING ASSEMBLY OF PUMP (2)

Replace top cover, screw in six cover screws finger tight, press in rocker arm, and then move it away from the pump body so as to flex the diaphragm (on A, B, and M models this action is reversed). At the same time, tighten the fixing screws alternately.

Diaphragm Spring

The body should now be reattached to the test stand, and the diaphragm spring placed in position—or a new one fitted if the old one is broken or distorted. It is of the utmost importance to ensure that the correct type of spring is fitted. Before refitting the diaphragm, examine it carefully; and unless all the layers are in perfect condition they should be completely renewed. Also see that the pull-rod is not badly worn where it engages with the linkage. When satisfied that the diaphragm assembly is in proper order, refit it by pressing it down as shown in Fig. 17 to overcome the spring resistance, and giving a quarter-turn when the end of the pull-rod engages with the linkage.

An important point to note at this stage is whether the holes in the diaphragm are properly in line with the screw holes in the body casting. If they are not, twisting of the pull-rod may result to such an extent as to cause it to foul the body, or make the linkage noisy in operation. Complaints of noisy pumps are sometimes traceable to this cause.

Diaphragm must be Properly Flexed

Replace the top cover assembly, and if the top-cover flange shows any sign of distortion, fit a cork gasket on top of the diaphragm. Screw in the six cover screws fingertight, move the rocker arm away from the

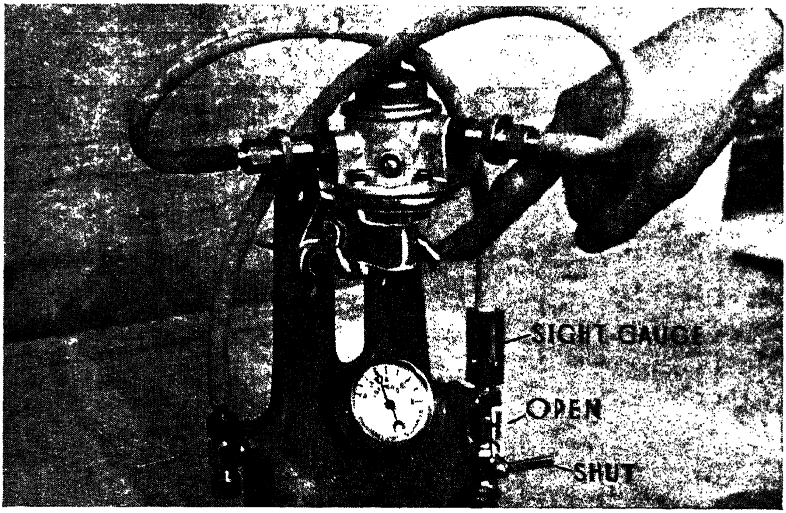


Fig. 19.—TESTING THE PUMP

Connect left-hand hose to inlet connection marked " In," and right-hand hose to outlet of pump. Open test cock, pump up on the priming lever, or rocker arm, about twelve strokes. This should lift testing fluid from reservoir, through pump, and fill the pipe-line. Shut off cock, again pump up, and pressure will be shown on test gauge. Pressure should remain for several minutes.

pump body so as to flex the diaphragm correctly, and at the same time tighten the fixing screws, on alternate sides, with a screwdriver (Fig. 18). The importance of flexing the diaphragm correctly cannot be over-emphasised. If the diaphragm is not properly flexed, an inefficient pump will result, causing starving at high speeds, difficulty in starting, and so on—if not a torn diaphragm.

It should be noted that it is impossible to flex the diaphragm correctly whilst the pump is still fitted to an engine.

Testing the Pump

The final operation is to test the pump. This is accomplished by connecting the left-hand hose of the test stand to the inlet connection marked "In," and the right-hand hose to the outlet of the pump. Open the test cock, and pump up on the priming lever (or rocker arm) about twelve strokes. This should lift the testing fluid (paraffin is recommended for safety's sake, but petrol may be used) from the reservoir of the tester, through the pump, and fill the pipe-line. Whether this desired result has been achieved or not can be ascertained by consulting the sight glass (Fig. 19). Next, shut off the cock, again pump up, and the pressure will

A.C. FUEL-PUMP PRESSURES

Make of car	*Model*	*Year*	*Pressure (lb.)*
Alvis	All	1929–34	1¾
Armstrong-Siddeley	20 h.p.	1933–38	¾
	Special	1933–37	
	Others	1931–39	
Auburn	—	1928–37	
Austin	7 h.p.	1932–39	
,,	Others	1931–39	2¼
Bedford	All	1931–39	2¼
B.S.A.	All	1932–39	2¼
Buick	60, 80, 90	1929–39	5
,,	Others	1929–39	
Chevrolet	All	1929–39	
Chrysler	All	1930–39	
Commer	All	1930–39	
Daimler	All	1930–34	3¼
	20–25 h.p.	1935–36	3¼
	15 h.p.	1935–39	2¼
Dennis	All	1930–34	2½
De Soto	All	1933–35	3½
Dodge	All	1934–39	4
Ford	8 h.p.	1932–39	1¾
	V-8	1933–39	3¼
,,	Others	1932–35	1¾
Graham-Paige	All	1934–39	3½
Hillman	Minx	1932–39	2¼
,,	Others	1931–39	3¾
Hudson	All	1934–39	3¼
Humber	12–14 h.p.	1933–38	3¾
	Others	1930–39	3¾
Hupmobile	All	1934–35	3½
Jowett	All	1932–39	1¾
Lagonda	All	1930–34	1¾
Lanchester	10 h.p.	1932–37	2¼
	18 h.p.	1932–34	
	12 and 18 h.p.	1934–39	¼
La Salle	All	1934–39	4
Oldsmobile	F35, L35	1934–39	3½ 4
Packard	120	1934–39	
Plymouth	PJ	1934–35	
Pontiac	All	1934–39	
Rover	Pilot	1932–33	
	Others	1932–33	¾
	10–12 h.p.	1933–36	1¾
	Others	1933–39	2
Singer	All	1930–34	2¾
,,	All	1937–39	
Standard	9 h.p.	1930–38	
,,	Others	1930–39	¼
Studebaker	All	1934–39	3½
Sunbeam	16–20 h.p.	1929–32	1¾
,,	20–25 h.p.	1933–34	1¾
Talbot	All	1929–32	1¾
	65 and 75	1933–36	1¾
	95 and 105	1933–36	3¼
	10 h.p.	1936–38	2¼
Vauxhall	All	1929–39	2¼

be shown on the test gauge. If the pump is O.K., the pressure will remain for several minutes. The correct pressures for the various types of pump are given in the table on p. 132.

When refitting the pump to the engine, make sure that the cam surface of the rocker arm rests against the eccentric and not under it, otherwise a broken rocker arm will result.

Special Points

Following are some special points to observe when overhauling particular types of A.C. pumps:

Series A and B.—(1) To detect whether the upper cover is distorted, place the filter bowl loosely in position without its gasket, and try to rock it. If slight distortion reveals itself, cure by fitting a new gasket; if the distortion is excessive, renew the cover. (2) Damaged glass filter bowls must always be replaced; alternative metal bowls are available if desired. (3) Poor delivery of fuel can sometimes be alleviated by fitting an air dome in place of the delivery-valve plug. (4) Move the rocker arm towards the pump body when flexing the diaphragm. (5) The normal diaphragm movement should be ·25 in.

Series A.—After refitting the rocker-arm pins, the ends of the holes in the pump body must be riveted over.

Series B.—Unless it is already fitted, substitute a lower protector of the same large size as the upper protector on the diaphragm, instead of the small size originally fitted. This will increase efficiency.

Series M.—(1) Move the rocker arm towards the pump body when flexing the diaphragm. (2) Normal movement of the diaphragm should be ·187 in.

Series Y.—(1) Move the rocker arm away from the pump body when flexing the diaphragm. (2) Normal movement of the diaphragm should be ·172 in.

Series T.—(1) Move the rocker arm away from the pump body when flexing the diaphragm. (2) Normal movement of the diaphragm should be ·26 in.

Maintenance

The AC petrol pump requires very little attention in operation, but periodically the sediment chamber should be inspected and, if necessary, cleaned out.

Where the sediment trap is a glass bowl attached to the upper half of the pump body, it is a simple matter to detect the presence of sediment.

Where the sediment trap is situated under the top cover, the cover should be removed (while the engine is stationary, of course), and the filter gauze lifted out. The presence of grit, etc., in the sediment chamber will then be apparent. Removal of the small screw underneath the inlet

connection will allow the petrol which is in the sediment chamber to drain off. Any grit, etc., which remains in the chamber may then be wiped out with the aid of a piece of rag over the end of a small stick. Replace the screw, gauze and cover, taking care that the cork gasket under the cover is in a good condition. It is a good idea to fit a new cover or sediment bowl gasket every time the sediment is removed.

WINDSCREEN WIPERS

By JOHN L. P. PINKNEY, M.S.A.E.E.

THERE are many types of windscreen wipers fitted to cars, but practically all of them work on the same principle. An early type, occasionally met with, consists of a cylindrical casing containing a solenoid coil, a plunger, and contacts. When current is switched on, the solenoid coil becomes energised and the plunger is drawn into the coil, but at the same time the plunger compresses two springs, so that when the contacts are opened at the completion of the stroke of the plunger, these springs supply the energy for the return stroke. At the end of this stroke the contacts close again, and the plunger is again drawn into the solenoid.

The Oscillatory Movement

One side of the plunger has teeth cut in it to form a rack, which engages with the teeth of a pinion wheel mounted in a bearing within the outer casing. The oscillating longitudinal movement of the plunger is then converted to an intermittent reversing rotary action to the pinion wheel. Attached to the spindle of the pinion wheel is the squeegee blade, which wipes across the windscreen.

The Time Lag

If this was all, the wiper arm would flash back and forth across the screen at a fast rate, and to prevent this a dashpot is fitted at the end opposite to the solenoid coil. On the end of the plunger is a leather washer which fits into the dashpot. When the wiper is first switched on, the dashpot allows the plunger to be drawn rapidly into the solenoid coil, but on the return stroke the springs tend to push the plunger back, but the dashpot prevents this until the air in the dashpot has had time to escape through an adjustable air leak.

Irregular Movement

Whereas the ordinary wiper sweeps across the screen at a regular speed, the solenoid type can be distinguished by the rapid sweep across the screen and then a distinct pause. The time-period of the stroke can be adjusted by the air leak.

Adjustments

When the strokes are too frequent, a few drops of oil on the leather washer, to make it more pliable, will render it more airtight, and this

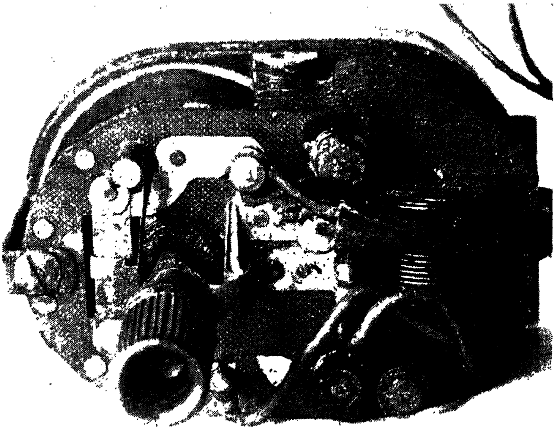
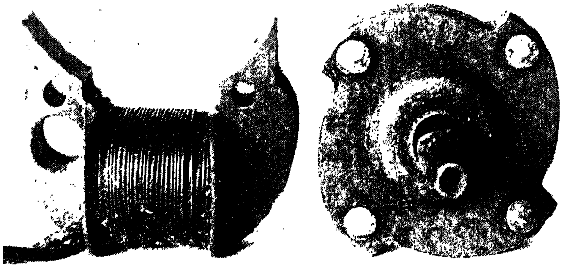


Fig. 1 (*left*).—THE IMPULSE MOTOR SCREEN WIPER

This shows the impulse motor with the cover removed, but with the switch and starting knob in position.

Fig. 2 (*right*).—IMPULSE MOTOR PARTS

The two main components of the impulse motor. The field coil is wound round the limb of the field poles which are laminated. The rotor is also laminated and these are rivetted together. The fibre cam can be seen on the shaft of the rotor.



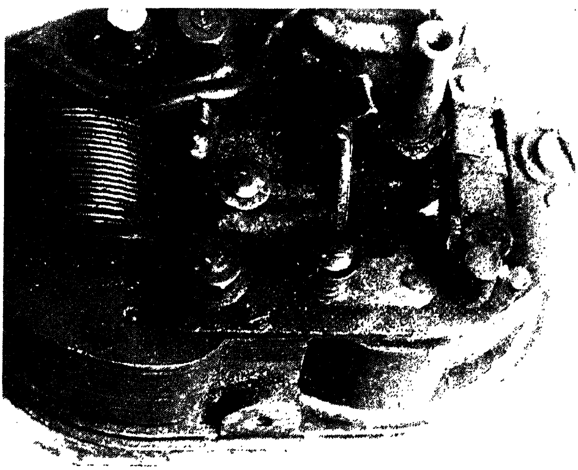


Fig. 3 (*left*).—IMPULSE MOTOR

This is a close-up view showing the make and break contacts on the right and the two bent brass strips forming the switch on the left of the shaft. The pulling out of the knob causes these two brass strips to come together, thus completing the electrical circuit.

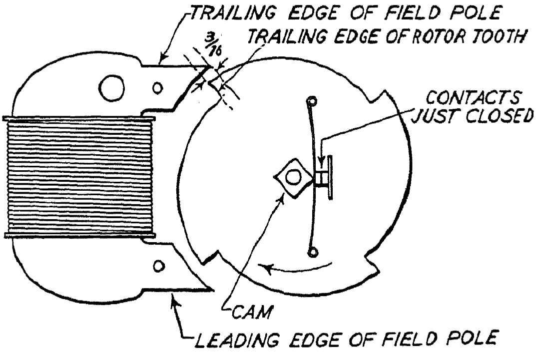


Fig. 4.—TIMING OF CONTACTS—CONTACTS CLOSED

The best position of the rotor in relation with the contacts is to have the contacts just closed when the trailing edge of the rotor tooth is approximately $\frac{3}{16}$ in. before the trailing edge of the field pole.

will lessen the number of strokes in a given time. A failure to work may be due to the internal switch making bad contact, and the switch blade should be bent to press more firmly on to the contact stud.

IMPULSE MOTOR-TYPE WIPERS

Most present-day wipers are operated by an electric motor which either forms a part of the wiper or is a separate unit. There are two patterns of motors in general use, namely, the impulse motor with synchronised "make-and-break" contacts, and the commutator motor.

The impulse motor is not self-starting, and the armature or rotor must be given a preliminary spin for it to continue to rotate. This motor has a peculiarly shaped laminated rotor which rotates between a pair of laminated pole-pieces set at an angle of approximately 90°. On the end of the rotor shaft is a square piece of fibre with rounded corners which actuates the opening and closing of the two contacts. There is only one winding, and that is the field winding, which is wound on the core of the laminated pole-pieces.

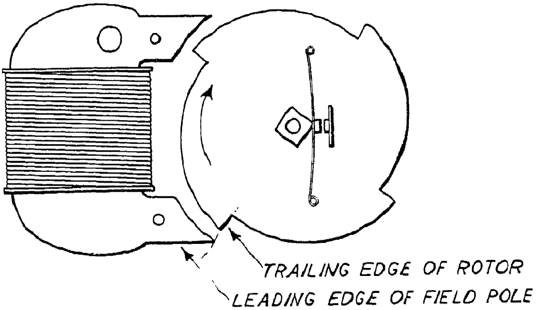


Fig. 5.—TIMING OF CONTACTS—CONTACTS OPEN

When the trailing edge of the rotor tooth is in line with the leading edge of the field pole, the contacts should just open.

Synchronised Impulses

The field winding is connected to the battery supply by way of the two contacts. The square piece of fibre on the end of the shaft opens and closes these two contacts in synchronisation with the position of

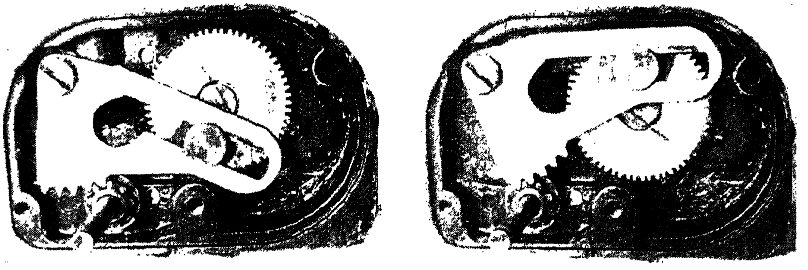


Fig. 6.—HOW MOTION IS TRANSMITTED TO THE WIPER

These two photographs show the two extreme opposite positions of the rack and from these can be visualised the backward and forward movements of the squeegee arm spindle. The rotor pinion drives the right-hand toothed wheel which in turn drives the large crank wheel.

the rotor teeth in conjunction with the pole-pieces. This position is very critical, and if the square fibre is forced round only very slightly, the rotor will refuse to rotate electrically and will lock itself magnetically to the pole-pieces.

The Starting and Stopping Switch

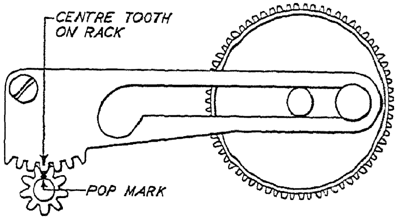
The operating switch for the motor is mounted close up to the rotor shaft, and consists of two bent pieces of brass. On the rotor shaft is an ebonite knob which projects outside of the wiper casing. It is this knob which has to be pulled out and given a twist to start the motor, and when the knob is pulled out it allows one of the brass strips of the switch to press against the other brass strip and thus complete the electrical circuit.

Timing of Contacts

When the fibre cam is out of adjustment it will be necessary to readjust the position of the contacts, by slackening off the two screws or nuts which hold the contact plate in position, and to move the plate backward or forward until the right setting is secured. The best setting is achieved by having the contacts just closed when the trailing edge of one of the rotor teeth is in front of the trailing edge of the field pole by approximately $\frac{3}{16}$ in. This will bring the trailing edge of one of the teeth of the rotor level with the leading edge of the pole-piece when the contacts just open. After the contacts have been set, the two screws holding the contact plate are again tightened. If the correct setting cannot be obtained by moving the contact plate, it is possible to slightly turn the fibre cam on the shaft, as this is only a tight fit.

Fig. 7.—ADJUSTMENT OF RACK

To give the squeegee arm its full sweep across the windscreen, mesh the centre tooth of the rack with the pinion at the pop mark. On the squeegee arm spindle are notches which are for the purpose of securing the squeegee arm, and these notches can be either at the top or bottom, depending on whether the motor is fitted at the top or bottom of the screen.



Broken Contact Spring

When the bow spring of the moving contact of the make-and-break is broken, it will be necessary to fit a replacement contact plate, and it ll also be necessary to retime the action as given above.

The Gearbox

The continuous rotary motion of the rotor has to be converted to an oscillating motion so that the squeegee is moved backwards and forwards across the screen. To enable this to be done, the rotor shaft drives through pinion wheels to a crank which in turn oscillates the pinion attached to the squeegee arm spindle. If the crank is removed at any time, and is replaced wrongly, the arc through which the squeegee arm moves may be lessened. The correct method of replacing the crank is to mesh the centre tooth (there are five) of the crank with one of the teeth of the squeegee-arm pinion, which is centre-popped.

COMMUTATOR MOTOR-TYPE WIPERS

Windscreen wipers having commutators and three-pole armatures are self-starting and have a larger driving power than the impulse motor. The gearbox is very similar to the one previously mentioned.

The Switch

On the outside of the wiper cover is a short arm which is riveted to a contact blade on the underneath side of the cover, and is therefore directly earthed to the cover. By turning the switch arm to the "on" position, the contact blade wipes over a brass connecting strip which is mounted on the brush-gear plate. With the brass contact strip in this position, the connecting strip is earthed, thus completing the circuit from the accumulator through the motor windings and to earth.

Parking Position of Squeegee

To enable the squeegee blade to be parked clear of the driver's vision, the squeegee spindle projects through the front of the motor casing and this portion is bent round to form a loop. With the switch in the

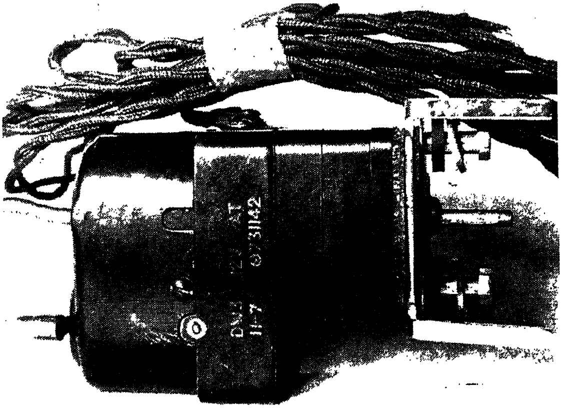
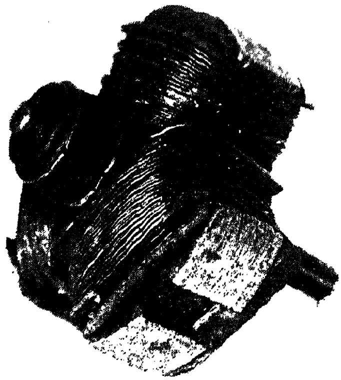


Fig. 8 (*left*).—COMMUTATOR MOTOR SCREEN WIPER

This is a complete wiper as sent out by the makers' with the fixing bolts and rubber washers and packing pieces. The looped end of the squeegee arm spindle is located in the "parking" position with the end inserted into the hollow of the switch handle.

Fig. 9 (*right*).—COMMUTATOR MOTOR SCREEN WIPER

Showing the three-pole armature with a pinion-drive shaft. The teeth of the pinion are cut out of the solid shaft.



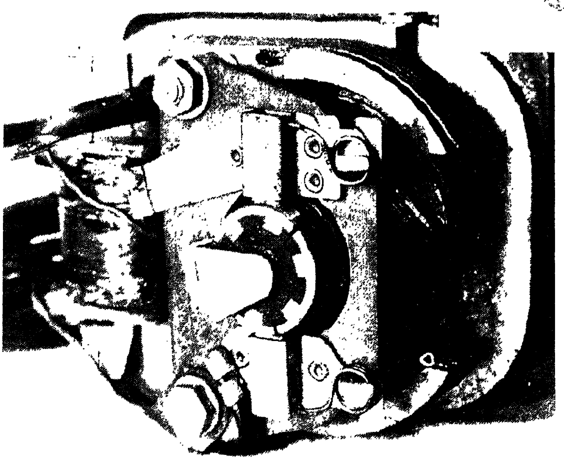


Fig. 10 (*left*).—COMMUTATOR MOTOR SCREEN WIPER

This shows the motor with its cover removed. Inside the cover is the switch blade which wipes over and makes contact with the connecting strip marked with a cross. The track made by this switch blade can also be seen on the insulated platform.

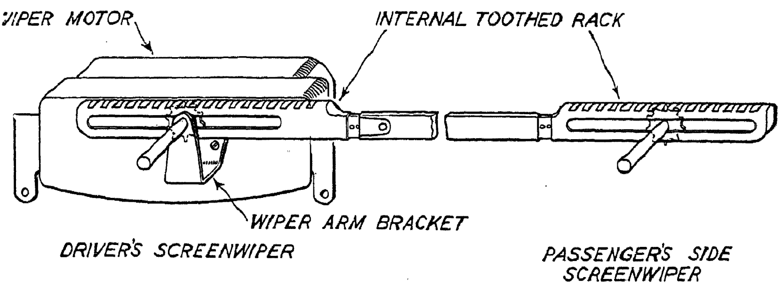


Fig. 11.—DUAL WIPER ARM RACKS

"off" position, the squeegee spindle can be pulled forward and turned so that the squeegee blade is in the parking position. This action is possible, since the squeegee spindle is put out of mesh with the motor gearing when the loop is pulled out. With the switch lever in the "off" position, the end of the loop can then be dropped into the hollow end of the switch lever, thus locking both the switch and the squeegee arm.

Twin-arm Wipers

To enable two arms to be linked together, various methods are used. One method is a toothed wheel fixed on the squeegee arm shaft on the outside of the motor unit. This wheel is in mesh with an internal toothed rack which is extended across the screen to a similar rack meshed with a toothed wheel driving the second squeegee arm. The rack drive is usually hidden in the bottom screen rail, which is cut away to take the gear.

Remote Motor Drive

The later method of dual-arm control is to have the motor minus the rack gear, but having a reduction gearbox fitted behind the dashboard, generally under the bonnet. The drive from the continuously rotating

Fig. 12.—REMOTE SCREEN-WIPER MOTOR

This is a commutator motor with a gearbox to reduce the speed to that required by the squeegee arms. The size of the motor is much larger than motors that are fitted direct on to the screen, and in consequence the power output is greater.

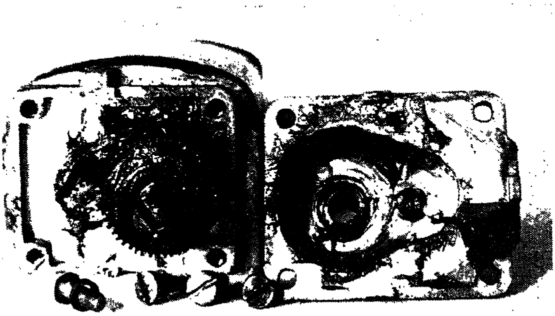


Fig. 13.—REMOTE SCREEN-WIPER MOTOR

Another type of remote motor with the gear-box cover removed to show the reduction gearing. The speed of the main shaft is higher in this type and the final speed reduction is carried out by a worm drive in the racking-box fitted in the bottom screen rail.

shaft of the motor gearbox to the rack mechanism is by means of a steel shaft coupled to the motor shaft by a rubber coupling. On the end of the steel shaft is a crank mounted in a bearing plate which is fixed inside of the bottom screen rail.

Squeegee Control

This crank is connected to the first clutch box and a further crank is taken from the first clutch box to the second clutch box. The clutch box for the driver's screen wiper incorporates a switch which switches on the motor. The screen wiper on the passenger's side can then be optionally "in" or "out" of action. When the driver pulls out the wiper knob and gives it a turn, the action puts the squeegee arm on to the screen, and engages the clutch with the racking drive and also switches on the motor.

Laminated Rubber Squeegee

The laminated rubber squeegee differs from others inasmuch as there are four separate thin strips of rubber instead of the usual thick strip. This makes for a smoother action and a cleaner sweep over the windscreen.

More Powerful Motor

The motor is more powerful, since it can be of a larger size, as the space it fits in is not restricted.

Less Noise

With the motor situated underneath the bonnet and near the engine, there is not that annoying buzzing sound that is common with other types mounted on the windscreen.

Flexible Drive

Another similar type of remote-motor wiper, and one more suitable where space is limited in the screen rail, differs mainly in the connecting link between the two wipers. Instead of having solid links, this type

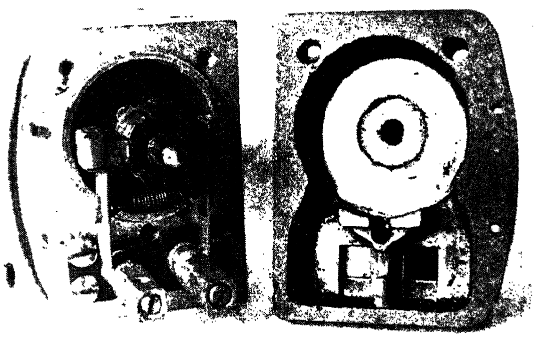


Fig. 14.—REMOTE SCREEN-WIPER MOTOR

Showing the commutator and brush gear with the main terminals. The brush tension is by means of a spring pulling the two brush arms together. The spring is anchored at each end to an insulating piece of hard fibre. The end cover has two square holes through which fits the main terminals so that connections can be made without removing the cover.

has a flexible drive, and the reduction gear-box is mounted on the screen rail instead of being integral with the motor. Also the drive from the motor to the reduction gearbox is flexible.

The Gearbox

Inside the gearbox is the crank wheel and crank arm which give the racking motion to the flexible link. On the flexible shaft are two racks, each of which drives, by means of a pinion and through a clutch, one of the two squeegees. Here again, the passenger has independent control of his wiper. An interesting feature is the construction of the flexible shaft. The shaft is very much similar to Bowden cable as used for operating brakes, etc., but to reduce wear and friction between the inner cable and the outer casing, steel balls are threaded on the inner cable.

Service to Screen Wipers

When a screen wiper is being tested on the car with a dry screen, an overload is imposed on the motor and more particularly on the mechanism. Although this will cause the motor to run hot in a very short time, the danger is the stripping of the gear wheels. The obvious protection is thoroughly to wet the windscreen before operating the wiper, and this should always be done unless the squeegee arm is removed.

Faulty Switch

A switch which will not operate may be due to a bent cover or to dirty contacts. If the contacts are dirty, they can be cleaned with very fine emery cloth. All connections should be examined for breaks and resoldered if necessary.

Sluggish Motor

If the speed of the motor is slower than usual, it is generally due to dried-up bearings, and these should be kept oiled. The gearbox, also, should be kept partly filled with high-melting-point grease. Do not

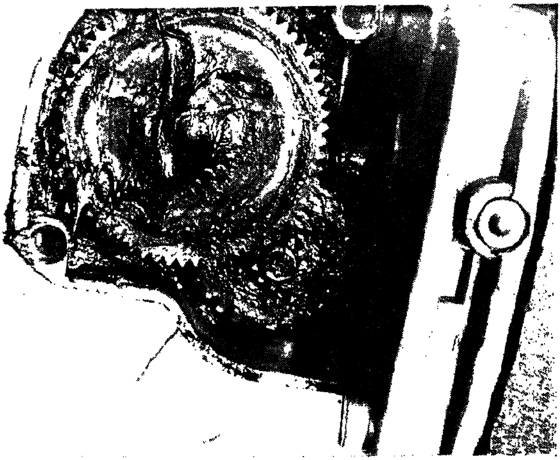


Fig. 15.—REMOTE SCREEN-WIPER MOTOR GEARBOX

This shows the gearbox of the motor together with the amount of grease put in by the makers. To diminish the armature speed to the slow speed required, the reduction gearing is by means of both worm and pinion. The worm on the motor shaft can be seen on the right of the large gear wheel.

forget the moving parts of dual arm controls, as these are apt to be overlooked, as they are out of sight. A little oil on these parts will lessen the load on the motor.

Sticking Brushes

Another cause for slow running is worn-out or sticking brushes. These should be renewed if worn sufficiently to prevent them making a firm contact with the commutator. Sticking brushes can be eased by cleaning them with a cloth and a few drops of petrol.

Dirty Commutator

The commutator can be cleaned by holding very fine sandpaper on its surface whilst rotating the armature by hand.

Burnt-out Motors

Burnt-out motors can be due to neglect on the part of the driver to switch off the wiper after it has stopped raining. To allow the wiper to continue in operation will cause the screen to dry up, and the increased friction between the squeegee and the screen may stall the motor without the driver being aware of it, and the motor is left switched on, with the result that the windings are burnt out.

BUILDING UP WORN PARTS BY OXY-ACETYLENE WELDING

By C. G. BAINBRIDGE, A.M.I.Mech.E.

THE worn surfaces of most metal parts can be built up with metal similar in composition to the original, and capable of being re-machined to the original size, so that the part will be equal to new. In many cases, the part may be built up with a metal which will provide a surface having qualities superior to the original.

On the other hand, parts may be surfaced, before being put into service, with a metal which will give superior wear-resisting properties to the wearing surfaces, as is done by the manufacturers of stellited valve-seat inserts.

Any ferrous metal may be surfaced with a lower melting-point non-ferrous metal; hard-facing metals may also be applied. It is not possible, however, to surface a metal with another metal having a higher melting-point.

It is immediately obvious that no one surfacing metal can possibly satisfy all the surfacing requirements; many different types of surfacing metals are now available, and they may be classified as follows:

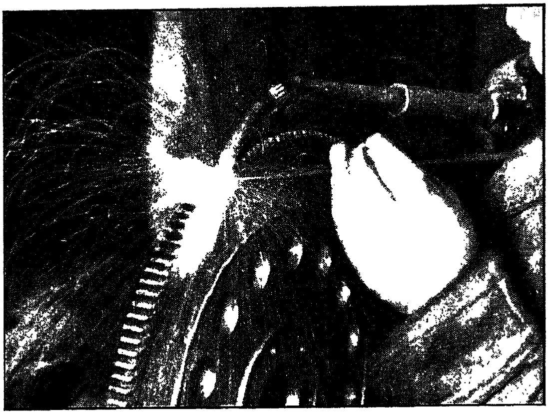
Type 1—Surfacing Metals similar to Base Metal

(*a*) Surfacing with a metal similar to that of which the worn parts consist (steel, cast iron, non-ferrous metals, etc.). Suitable for gear teeth, splines, worn holes, etc.

(*b*) Surfacing steel with an iron-base hardenable metal similar in composition to base metal. Suitable for cams, push-rods, etc.

As these welding rods are similar in composition to the base metal the melting-point is also similar, so that the ordinary fusion welding technique, i.e. intermixing of the deposit and base metal, is used.

(*c*) Application to steel of special iron-base welding metal such as carbon chromium-manganese, or chrome-vanadium alloys. Suitable for parts subjected to excessive shock and moderate abrasion. As the composition of the surfacing metal is different from that of the base metal a surface-fusion technique is used in order to avoid intermixing suitable for parts of sand and ballast handling plant, excavating machinery, etc.



1.—BUILDING UP WORN TEETH ON STARTER
(*From the "Oxy-acetylene Welding Repair Manual," Porteous Ltd., London.*)

Deposits are moderately hard "as deposited," cannot be machined, but can be shaped by grinding or forging and can (if necessary) be hardened.

Type 2—Non-ferrous Surfacing Metals

The surfacing of ferrous and non-ferrous parts with non-ferrous metals, e.g. bronze, in order to resist corrosion, reduce friction, and ensure machinability. This is a *non-fusion* process, i.e. the base metal is heated only to the melting-temperature of the surfacing metal. For further description see page 151.

Type 3—Hard-surfacing Metals

Hard-surfacing by means of special composition ferrous and non-ferrous alloys, in order to resist conditions of severe abrasion, corrosion, heat-softening, and shock. *A surface-fusion* process.

Depositing Techniques

The technique of depositing surfacing metals is often somewhat different from the usual fusion jointing techniques. Metals similar in composition and melting-point to the base metal are, of course, fused on to or inter-alloyed with the base metal, using a neutral flame as in ordinary joint welding ; this is a "fusion" technique.

When, however, the compositions and melting-points of the surfacing and base metals are different, it is usual to employ some form of "non-fusion" or "surface fusion" technique, in order to prevent inter-alloying of the metals. This avoids dilution of the surfacing metal with the base metal, which is likely to lower the value of, or eliminate entirely, some or all of the special characteristics intended to be provided by the various elements involved in the surfacing metal.

When steel is the base metal, iron- or cobalt-base alloys may be deposited without inter-alloying but with a perfectly reliable bond by creating a state of surface fusion of the base metal. The creation of this surface fusion relies on the fact that hot steel will absorb carbon, that a

high-carbon steel melts at a lower temperature than a low-carbon steel, and that an oxy-acetylene flame embodying an excess of acetylene contains free carbon.

When an oxy-acetylene flame having an excess of acetylene is applied to steel, the surface is heated until it absorbs sufficient carbon to melt at a lower temperature than the melting-point of the metal immediately under the surface. This phenomenon produces what appears to be a wet or "sweating" surface on the steel, and "the sweating condition" is the term generally used by welders to describe this state of surface fusion.

The high-carbon skin has, of course, no measurable thickness and does not contribute in any way to the hardness of the deposit, as the infinitesimal proportion of carbon is diffused in the surfacing metal as soon as it is deposited.

Surface metal deposited on to such a sweating surface has a perfectly strong reliable bond which will not split or flake off in service. This should be obvious from the fact that this type of bond is used for the application of surfacing metal subjected to the most severe shock and abrasive conditions, such as the surfacing of worn railway crossings.

Apart from the prevention of dilution of the surfacing metal, this technique has considerable value in that it avoids disturbance of the base metal; this is a valuable point when the base metal is in itself a steel of special composition and characteristics.

Surface fusion or sweating can be employed only for iron- and cobalt-base depositing metals and when the base metal is steel; cast iron will not sweat, neither will non-ferrous metals. When it is necessary to deposit an iron- or cobalt-base alloy (which melts at a temperature near that of cast iron) on to cast iron, the surface should be built up in two layers. The first layer must be more or less fused with the cast iron; the surface so produced, although an alloy of deposit and base metals, will sweat under the conditions described above, ready for the reception of the second layer of surfacing metal.

When non-ferrous metals, such as bronze, are deposited on to steel and cast iron, or a non-ferrous metal of higher melting-point, such as copper, it is not necessary or desirable to produce even this state of surface fusion, and the bronze is deposited at a base-metal surface temperature approximately equal to the melting-temperature of the bronze, i.e. with a non-fusion technique.

GENERAL PRACTICAL NOTES ON THE PREPARATION OF SURFACES AND THE DEPOSITION OF SURFACING METALS

Building up Gear Teeth, Splines, etc.

When building up small narrow surfaces, such as gear teeth, splines, etc., do not attempt to deposit too much metal in one run. It may be necessary to deposit several runs in order to build up to the desired

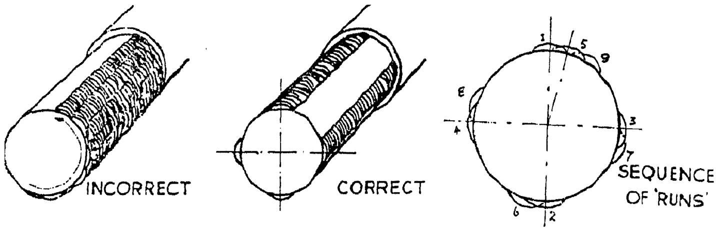


Fig. 2.—BUILDING UP WORN PORTION OF SHAFT
Showing right and wrong sequence in depositing the "runs."
(*From the "Oxy-acetylene Welding Repair Manual," Porteous Ltd., London.*)

depth, but it is easier to control the molten metal in small runs than it is in a heavy run which, moreover, usually leads to the deposition of more metal than is necessary. Care should be taken to see that each run of metal is thoroughly amalgamated with the previous run.

Examine for Cracks

Badly worn surfaces which have been subjected to severe impact when in service should be carefully inspected for cracks or flaws before resurfacing is attempted. If cracks are found to be present the surface must be removed by machining or grinding to a sufficient depth to ensure that the cracks are entirely removed.

Large surfaces should be covered by laying down a series of beads, or runs of weld metal; no attempt should be made to flow the weld metal over large areas, otherwise lack of bond between weld metal and base metal is sure to result.

This applies especially to the fusion technique, and the depositing of bronze on to ferrous metals with the non-fusion technique.

When it is necessary to build up a point or edge, which has been entirely worn away, copper backing-plates may be used as a mould or support for the deposit metal. Carbon plates may be used in the same way for bronze surfacing.

In cases of excessive wear, it is usually not economical to build up the whole of the worn portion with high-grade surfacing metals; a lower-grade wear and impact-resisting metal may be used for building to approximately the original shape, leaving just sufficient allowance for an overlay of hard surfacing metal. If the wear has been very great, it may be possible to weld an entirely new piece of metal on to the worn surface, surfacing metal being applied to the new metal surface or edge.

Note.—Low-strength, joint-making welding rods are not suitable for building up underlays for hard-surfacing metals, as they do not usually provide sufficient support for the hard surface.

Building up Shafts

In building up the worn portions of shafts, do not start at one place on the shaft and continue to deposit metal until the whole surface is covered. Lay down beads of weld metal parallel to the axis of the shaft, that is, in line with the centre line. After laying down the first run, turn the shaft 180° and lay down the second bead on the opposite side to the first run. After completing the second run turn the shaft 90°, and lay down the third bead between the first and second, after that lay down the fourth between the first and second opposite to the third, and so on, always placing each run opposite the previous run. In this way the heat is applied to the shaft uniformly and there will be little or no tendency for the shaft to distort.

The built-up portion of a shaft should be reheated after the surfacing is completed and then allowed to cool down slowly and uniformly.

Short, large-diameter articles such as rollers need not be " quartered " in this way. The deposit should still be applied in beads parallel to the axis. But the heads may be laid down one following the other around the circumference of the roller.

Large shafts or, in fact, any large parts, should be preheated before commencing to lay down weld metal.

Large articles or surfaces may necessitate the employment of a second operator with a blowpipe keeping the job hot during depositing.

As far as possible, always arrange for the average level of the depositing surface to be horizontal. Small parts can be preheated with the blowpipe, but larger parts will necessitate proper arrangements.

Building up Metal on Castings

Castings must always be preheated in order to reduce the risk of setting up local stresses during welding or when the weld metal cools, and to prevent distortion due to contraction of the weld metal. Preheating increases the speed of deposition and saves oxygen and acetylene.

Oil or grease must be removed from the depositing surface, otherwise gasification may cause porosity of the deposit.

Preheating may be carried out in proper muffles, or in temporary gas- or charcoal-fired loose firebrick furnaces such as those used for the preheating of castings for welding. The value of the latter type is that the part can be surfaced while still in the furnace, whereas muffle-heated jobs have to be removed for surfacing. This does not matter for steel parts, but it is dangerous for cast iron due to the risk of local cooling causing cracking.

Slow cooling is also just as essential as slow preheating.

Use the "Forward" Method

The " forward " or " leftward " method of depositing will generally be found best, as the forward heat of the flame preheats the surface on to which the metal is to be deposited.

The angles of blowpipe and welding rod for both techniques should be similar to those used for ordinary fusion-joint welding.

The Blowpipe

Ordinary single-jet welding blowpipes are suitable for most resurfacing work, but for very large areas the welder would do well to consider the employment of blowpipes having two or three jets.

How to avoid Flaking Off

Great care should always be taken to make sure that the deposit metals are thoroughly fused with (or in the case of surface fusion or non-fusion techniques, united with) the edges of the surface to be built up. Neglect to ensure this may result in deposit metal chipping away or flaking off from the edges of the deposit. It is often better to make sure of edge fusion or unity with the base-metal surface by laying down a separate bead of metal along the edges, instead of relying on the greater mass of deposit metal being worked out to the edges. Overhang of deposit metal should be generally avoided.

Flux

No flux is required for depositing steels, but the appropriate fluxes supplied for bronze and cast-iron welding should be used for these metals.

Application of Hardenable Surfacing Metals

The following notes amplify the brief notes already given regarding the various types of steel welding rods.

The application of hardenable deposits is only recommended for parts having small edges subjected to excessive wear, such as the ends of punches, cams, small cutters, knives, and dies.

With this type of rod the deposit, in the "as welded" condition, is soft enough for machining and shaping, the required hardness being obtained by reheating and quenching.

The hardness depends somewhat on the carbon content and method of quench employed, but hardness in the region of 600 Brinell is easily obtainable; in the case of steel deposits the hardness may be lowered by tempering. Cast iron provides an excellent hard surface when quenched, provided the area of the deposited surface is not too large. In the "as deposited" condition, without rapid cooling, the deposit hardness usually varies between 200 and 350 Brinell.

Surfacing with Bronze

Surfacing with bronze avoids melting the base metal so that this process is, of course, excellent for building up worn or missing portions of malleable-iron castings. For the same reason, the necessity for preheating is often eliminated, so that bronze deposits can be made without

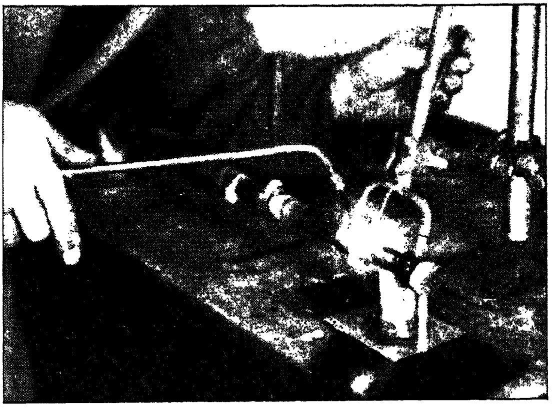


Fig. 3.—BUILDING UP WORN CAMS WITH CAST IRON
(*From the " Oxy-acetylene Welding Repair Manual," Porteous Ltd., London.*)

dismantling the part. Bronze surfaces have a low coefficient of friction, are easily machined and have excellent wear- and corrosion - resisting properties.

When surfacing with bronze it is important to provide a thoroughly clean surface on to which the bronze is to be deposited. Oil or grease must be removed. On shafts, the surface is quite well prepared by ordinary machining, but on flat surfaces the surface may be cleaned by filing, chipping, or sand-blasting. If cast-iron surfaces are ground it has been found advisable to either sand-blast afterwards or to heat the surface with the oxy-acetylene flame, before depositing, in order to remove the surface graphite.

The surface must be " tinned " (with the bronze welding rod) in conjunction with a suitable flux before building up to the full bronze thickness required. The tinning operation is most important on cast iron and care must be taken to make sure that molten bronze does not run on to untinned surfaces. On steel, tinning proceeds ahead of the depositing more or less automatically, but on cast iron the welder must make sure that he actually tins the surface ahead of the bronze deposit.

General experience has shown that the best welding conditions are obtained when the oxy-acetylene flame is adjusted to a slightly oxidising condition ; not only does this promote a better bond between the bronze and the parent metal, but it prevents volatilisation of the zinc, and enables a better control of the molten metal to be obtained. Flux is applied before welding by mixing to a paste and painting on to the surface to be built up, and during welding the heated end of the welding rod is occasionally dipped into the flux. Preheating temperature need not be more than black hot or very faint red, the bronze depositing temperature being approximately 850°–900° C.

If the deposit surface becomes too hot, or is not hot enough, difficulty will be experienced in getting the bronze to " tin."

There is only one limitation to the use of bronze as a surfacing metal ; this is that bronze begins to yield as soon as a temperature of approxi-

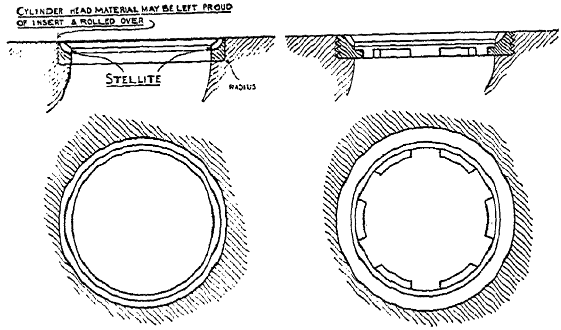


Fig. 4.—TWO TYPES OF STELLITED VALVE-SEAT INSERTS

The insert is made of good-quality medium carbon steel, ·2 to ·4 per cent. carbon, with either an interference fit (·006–·008 in., on outside diameter) or is screwed into cylinder block. Thickness of Stellite after grinding, not more than ·060 in. (*Deloro Smelting & Refining Co., Ltd.*)

mately 500° F. is reached, consequently it should not be employed where the finished work may be subjected to temperatures in excess of 500° F.

Hard-facing

There are several types of hard-facing metals, each being suitable for a specific type of application according to the wear to be resisted, the extent of the surfacing, and the expense that the job will stand.

"Stellite," probably the best-known cobalt-base hard-surfacing alloy, combines excellent welding properties with maximum wear-resistance, and is highly resistant to abrasion. When cold it is almost as hard as hardened steel, but its most unique and useful property is that it retains its hardness even at red heat, which renders it especially suitable for the surfacing of engine-valve seats.

Stellite is itself available in several grades, according to the hardness of ductility and, therefore, the resistance to impact, which is required.

Grade 1 is the hardest, and should be used wherever severe abrasion is to be resisted; Grade 6 is softer and is generally recommended for building up valves and valve seatings.

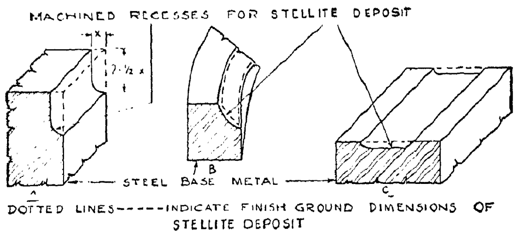


Fig. 5.—METHODS OF PREPARATION FOR DEPOSITING STELLITE

(A) shows preparation required for Stellited corner which is to be subjected to shock. (B) method of shaping a steel valve-seat insert. (C) preparation for longitudinal area to which Stellite is to be applied.

The hardness of a hard-surfacing metal is not dependent upon the mass of metal upon which it is deposited, so that the hardness will be the same whether the deposit is made on large or small articles and whether the deposit is thick or thin. As hard-surfacing alloys are expensive it is

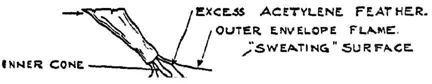


Fig. 6.—STELLITING

Applying flame to produce "sweating" of the steel to be surfaced with Stellite.

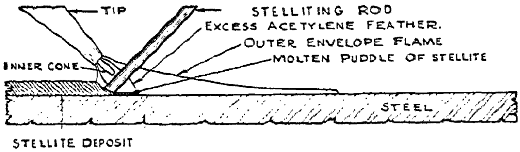


Fig. 7.—STELLITING

Depositing the Stellite, showing end of rod melting and forming a puddle on the "sweating" steel surface.

desirable to make the coating as thin as possible, in fact a thin coating is subjected to less puddling, agitation, and overheating than a thick deposit.

All hard-facing alloys are intended to be applied without interalloying them with the base metal, i.e. with a surface-fusion technique.

The mixing of base metal with Stellite would lower its red hardness and abrasion resistance.

The Preparation of Parts for Stelliting

In the preparation of parts for Stelliting, for example valve-seat inserts, sharp edges or corners must be avoided, as these are liable to scale or oxidise and prevent the Stellite from bonding with the surface of the edge or corner. An external radius is not required ; all that is necessary is to remove the sharp edge. Internal corners should also be well radiused. Surfaces to be Stellited should be arranged horizontally. Surfaces must also be clean and free from surface scale, oil, or grease, or any other foreign matter. A ground or machined surface is the best. Cast-iron flux should be used when depositing on to cast iron, and is sometimes found useful for steel.

The excess acetylene flame should be two to three times as long as the normal neutral cone. The flame should be as "soft" as possible ; this can be obtained by reducing the gas pressure below the usual recommendations for the particular nozzle being used. Use the smallest-size nozzle which will give sufficient heat for the job. The depositing surface is brought to the sweating condition as already described.

The Stelliting Process

The welding rod is applied between the inner cone of the flame and the hot base metal. The majority of the heat from the flame is directed upon the rod, which melts and forms a puddle on the sweating steel surface. If the base metal is at the right temperature this puddle will spread uniformly, and an entire surface can be covered by manipulating the welding rod and blowpipe flame in this way. When depositing is finished, withdraw the flame slowly.

The extent of the sweating area around the end of the blowpipe flame will, of course, vary according to the size of nozzle in use, but provided the base metal has been brought up to a high temperature to begin with, sweating proceeds more or less automatically as the surfacing continues.

Preheating temperature should be about 800° F., that is, a very faint red when viewed without goggles in a darkened room. It is essential that the preheating temperature shall not be too high, otherwise the metal may scale, while if the preheat temperature is not high enough more blowpipe heat will be required in order to produce the sweating condition, thus increasing the cost of the process. Preheating also avoids sudden chilling of the deposit metal, which may cause cracking, the ductility of most hard-facing materials being very low. Jobs having a large surface to be hard faced should be preheated and surfaced in a temporary charcoal or gas furnace so that the heat can be maintained while the surfacing is proceeding.

During depositing, hard-surfacing metals are liable to be detrimentally affected by too much heat, or excessive agitation, so that care should be taken to make sure that neither the base metal nor the welding rod is overheated. From the point of view of both economy and satisfactory surfacing, the deposit should be laid down as thinly as possible.

After Stelliting

Cool slowly in order to produce a deposit free from cracks and internal stresses. Small parts can be taken as soon as deposited and placed in a box containing powdered mica, lime, ashes, or other heat-insulating material, so that they will cool slowly.

After depositing, the deposited metal may be reheated with the welding blowpipe, so as to flow the surfacing metal to a smooth finish, free from the irregularities which occur during the initial depositing.

Hard-surfacing metals will not withstand shock unless supported by base metal, so that overhang must be avoided. If overhang occurs it must be ground off before the article is put into service.

Hard-faced deposits can only be finished or smoothed by grinding. Care should be taken to use a soft-grade vitrified wheel running at a speed of between 3,000 and 4,500 surface ft. per minute.

Hard-surfaced parts, of course, must never be cooled by dipping in water.

Building up Worn Cams

If re-machining or cam-grinding equipment is available, cams may be built up with a hard-surfacing metal (Class 3) or cast-iron welding rods. This type of repair is not recommended if more than two (or at the most three) cams are worn badly, owing to the high cost of grinding, although other circumstances might necessitate this type of repair. Mount the shaft in vee supports. Build up the cam to the required amount, and

while the deposit is still at a cherry-red heat, quench by dipping the shaft vertically in water. Repeat for each cam. Fig. 3 shows a good method to prevent warping of the camshaft—a jet of water being projected on either side of the cam being treated. To enable a sharp edge to be obtained after grinding, allow the deposit to slightly overhang the sides of the cam.

Gear-selector Forks and Crown Wheels

To repair gearbox selector forks and crown wheels made of aluminium bronze, a special aluminium-bronze welding rod and an aluminium-bronze or cryolite flux must be used in conjunction with an excess acetylene flame. Clean the edges to be welded carefully, and preheat the part to almost welding temperature with the blowpipe before commencing the welding operation. Heat the end of the rod and dip it into the powder flux. When welding, move the rod vigorously in the weld pool to break up and remove the aluminium oxide which forms on the surface of the pool as a brown skin. This clings to the end of the rod, and should be occasionally removed by tapping the rod on the bench or by melting the end of the rod on to the bench or floor. Keep a large area well heated, and then add the filler metal quickly without getting very deep fusion.

ELECTRIC SPEEDOMETERS

By JOHN L. P. PINKNEY, M.S.A.E.E.

TOTAL mileage and trip records were at one time of far more importance than was an indication of the car's speed, but ever since restrictions were imposed on speed in certain areas an accurate indication of the car's speed is now demanded. This accuracy can be achieved by electrical means and with more flexibility than with the mechanical speedometer with its flexible-shaft drive.

Trip Records

One of the main drawbacks to the electric speedometer is the inability, without undue expense, of incorporating recording mechanism. One way to overcome this drawback is the fitting of the mileage-counter mechanism in the dynamo casing. In this situation, the dynamo must be mounted in a position affording easy access to enable readings to be taken. The mechanism can also be electrically operated, in which case the indicator can be fitted on the dashboard.

Principle of Speedometer

The working principle of the electric speedometer is a permanent-magnet dynamo driven from any rotating part of the car, e.g. the gearbox.

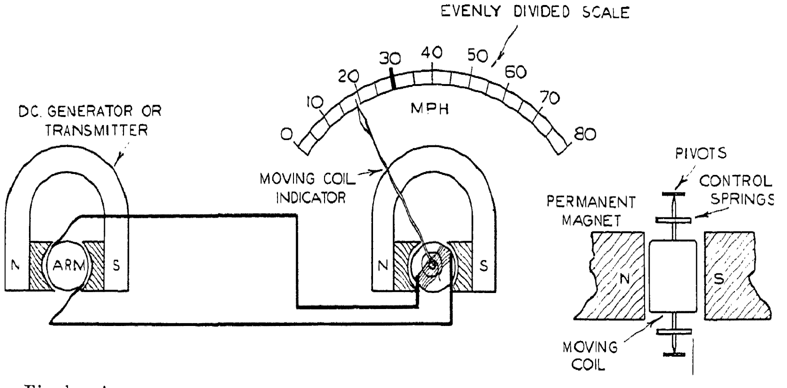


Fig. 1.—ARRANGEMENT OF AN ELECTRIC SPEEDOMETER USING A PERMANENT-MAGNET D.C. DYNAMO COUPLED WITH A D.C. MOVING-COIL METER AS AN INDICATOR

Note the evenly divided scale.

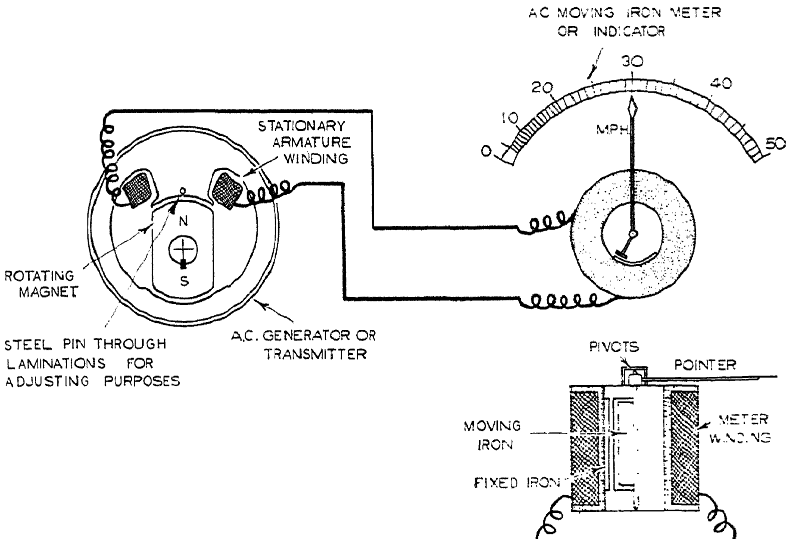


Fig. 2.—ELECTRIC SPEEDOMETER WITH AN A.C. DYNAMO CONTROLLING AN A.C. METER
Note the uneven scale on the indicator. Both the dynamo and the indicator are simpler than the D.C. arrangement, and manufacturing costs are lower.

The indicating device is a voltmeter which is connected to the dynamo by two wires.

If the armature current is kept small, as it will be if the voltmeter is of high resistance, the field will be constant in value, since there would be a negligible cross-field to upset the permanent magnet. Under these circumstances, the volts generated by the dynamo will be in direct proportion to the dynamo's speed, so that if a moving-coil voltmeter, with the scale calibrated in miles per hour, is used, the scale reading will be evenly divided. But with this system there is one disadvantage, and this is that by using a direct-current dynamo, with its rotating winding and brushes, much attention is needed to ensure constant, accurate working.

Alternating-current Dynamo

One way to overcome this disadvantage is to employ an alternating-current dynamo in conjunction with a moving-iron voltmeter. The dynamo in this instance would consist of a rotating-magnet field, with the armature winding stationary, and thus dispensing with rubbing contacts. Also, a direct-current dynamo costs more to manufacture than an alternating-current dynamo.

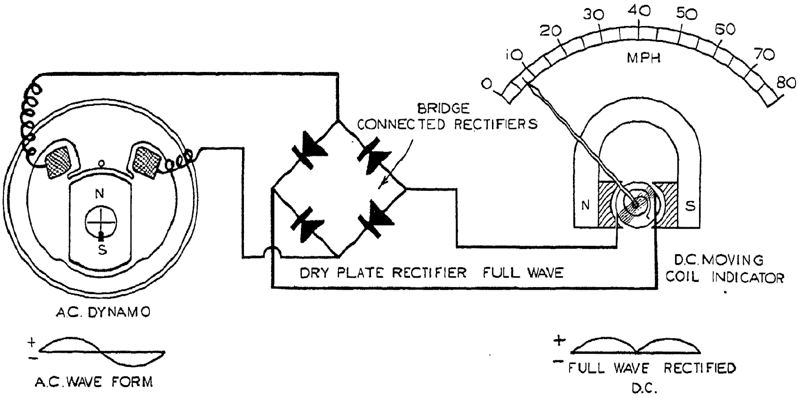


Fig. 3.—THE RECOGNISED SUPERIORITY OF BOTH THE A.C. DYNAMO AND THE MOVING-COIL INDICATOR, WITH ITS EVEN SCALE, ARE SHOWN HERE CONNECTED TOGETHER : OF A FULL-WAVE DRY-PLATE RECTIFIER

Here, again, there is one drawback to this system, and it is that a moving-iron instrument has a scale which is not evenly divided but is generally cramped at the beginning, with the remainder of the readings widely spaced. This sort of scale is satisfactory inasmuch that the important thirty-miles-per-hour reading can be arranged in the centre of the dial, but low readings are more difficult to read with extreme accuracy as, with these cramped together, even the thickness of the pointer would introduce uncertain errors. One great advantage of the moving-iron meter is its simplicity and low cost.

Rectified A.C.

There can be no denying that the alternating-current dynamo is the best to use, since it demands very little attention and this is for oiling only, and there is also the advantage of the lower manufacturing costs. Also, the moving-coil type of indicator is the best if accuracy of reading is demanded over all of the scale. These two units can be used together, that is, an alternating-current dynamo can be employed in conjunction with a direct-current moving-coil indicator by incorporating a rectifier in the circuit.

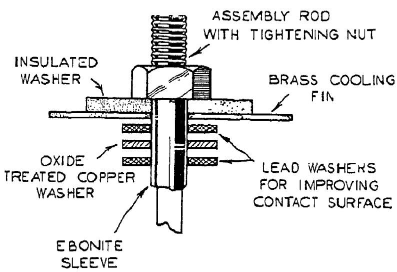
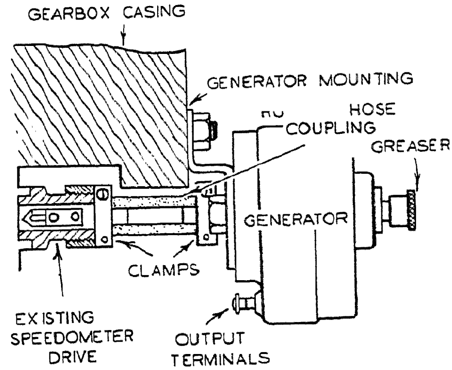


Fig. 4.—CONSTRUCTION OF THE ELEMENTS OF METAL RECTIFIER

This has been made a simple

matter by the introduction some years ago of the dry metal-plate rectifier, which converts alternating current to direct current. This type of rectifier is used for battery charging and is described on p. 40.



5.—SPEEDOMETER DRIVE WITH FLEXIBLE RUBBER COUPLING TO GENERATOR

The Drive

The dynamo can be designed for belt drive off the transmission shaft by fitting a split pulley on the shaft. This design is useful on those vehicles not provided with a speedometer drive on the gearbox, as the fitting up of the dynamo and the split pulley can be carried out with but little trouble.

When a speedometer drive is provided in the gearbox, special adaptor plates are supplied to enable the dynamo to be fixed in position.

When the drive is below oil level, the dynamo is fitted with suitable oil seals to prevent the oil penetrating through to the inside of the dynamo and its windings.

Flexible Drive

On some existing drives, no room is available to fit the dynamo in position, and in such cases the dynamo is fitted on a platform which is secured on to the side of the gearbox. The drive is then by means of a short length of rubber tubing, which takes care of any maladjustment between the dynamo and the existing drive. Also, with this mode of fixing, there is no trouble with oil leakage, and therefore there is no necessity for fitting oil seals in the dynamo bearings.

Voltage Calibration

Means must be provided to enable the indicator to register the correct speed of the vehicle and to allow of the units being interchangeable with each other. This calibrating is essential, since the speed at which the dynamo will be driven for a corresponding road speed of, say, thirty miles per hour will differ for different makes and types of vehicles. The r.p.m. for a speed of thirty miles per hour will be in the region of 1,300 to 2,000.

Adjusting Strength of Magnet

One method of adjusting the voltage output of the dynamo is to employ magnets of various thicknesses to suit a certain range of speed. The

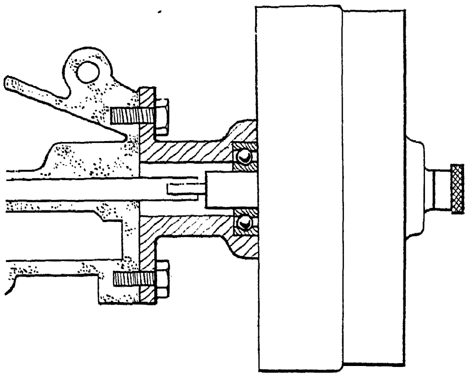


Fig. 6.—A.C. GENERATOR COUPLED TO EXISTING SPEEDOMETER DRIVE IN GEARBOX

final calibration is then taken care of by short-circuiting part of the magnetic flux by means of steel adjusting screws, which can be adjusted to vary the air gap between the outer casing and a steel pin which passes through the field laminations.

Weakened Field

This shunting of part of the magnetic flux will lessen the number of lines of force cutting through the turns of wire on the field winding, and the voltage generated across this winding will be diminished.

Variable-resistance Calibration

Another method of calibration is by adjusting the amount of resistance wire placed in series with the indicator, so that a portion of the current, which would otherwise help to increase the reading on the indicator, is dissipated in heat. The use of Eureka resistance wire also assists in correcting temperature errors which are likely to arise with the varying temperatures of the dynamo winding.

THE VAUXHALL ELECTRICAL SYSTEM

10-H.P. CARS

The wiring diagram for Vauxhall 10-Four cars is given on page 88.

To Remove Dynamo

TO remove the dynamo, disconnect all leads; slacken off as for adjustment of belt, but in this case remove the fan belt. Remove the bolt from the link and the rear bolt underneath the dynamo, also the nut and washer from the front mounting stud, when the dynamo can be moved forward to clear the stud.

To Dismantle Dynamo

Remove the dynamo brushes. Remove the armature-shaft nut and washer and draw off the pulley, utilising a drag, such as Britool Drag No. 834A. Remove the woodruff key. Remove the nuts from the through bolts which pass through both endplates. Remove the commutator endplate.

Carefully withdraw the driving-end bracket assembly together with the armature. After removing the driving-end bracket, the armature can be carefully pressed out. To remove the ball bearing from the drive endplate, take out the three screws, so releasing the bearing-retaining plate.

The tension of the brush springs can be tested with a small spring scale and should be within the limits of 15–25 ounces.

Assembly of the dynamo is merely a reversal of the order of operations for removal.

When assembling the pulley endplate, do so in the following order: felt retainer, felt, spring, bearing, bearing-retainer plate. Then insert the three screws. Place the cupped washer on the shaft with the dished side inwards, and press the end cover on to the shaft. Dowels locate both end covers, so that no mistake is possible. Thoroughly tighten the through bolts. Fit the shaft and pulley key before pressing on the pulley.

CONTROL BOX

The control box, which is attached to the left-hand side of the dashboard underneath the bonnet, houses a voltage regulator, cut-out, and fuses.

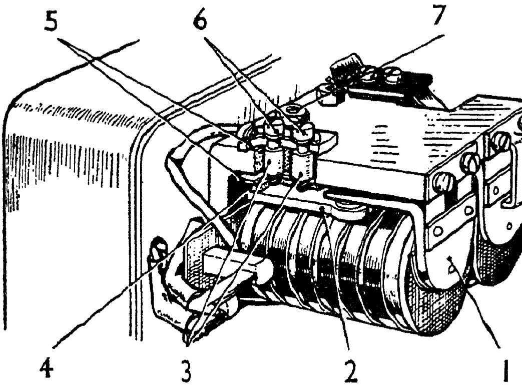


Fig. 1.—VOLTAGE REGULATOR

Frame cut away to show mounting of fixed contact plate. 1. Regulator armature. 2. Fixed contact plate. 3. Insulating bushes. 4. Packing plate. 5. Insulating plates. 6. Screws securing fixed contact plate. 7. Regulator adjustment screw.

If any electrical accessories are fitted they must be connected to one of the terminals in the control box marked A4 or A2. Connection to any other point will damage the dynamo controller. It is preferable to use terminals marked A4, but in the case of some equipment (such as a car radio set) this would prove inconvenient, as it would be possible to operate the accessories only whilst the ignition was switched on. In such cases the terminal marked A2 should be used.

Voltage Regulator

The voltage regulator operates in conjunction with the dynamo, automatically varying the output according to the load on the battery and its state of charge. The regulator also incorporates a temperature compensation which adjusts the setting to suit climatic conditions and which also causes the dynamo to give a controlled boosting charge at the beginning of a run. The regulator is combined structurally with the cut-out.

Regulator Adjustment

The regulator is carefully set before leaving the factory to suit the normal requirements, and in general it should not be necessary to make any alterations to this setting. If, however, the battery fails to keep in a charged condition, or if the dynamo output does not fall when the battery is fully charged, it may be advisable to check the setting and if necessary readjust.

It is important before altering the regulator setting, when the battery is in a low state of charge, to ensure that its condition is not due to a battery defect or to dynamo-belt slip.

For adjustment, proceed as follows :

Withdraw the cables from the terminals marked A and A1 in the cut-out and regulator unit, and join them together. Connect the negative lead of a voltmeter—which should be a high-grade moving-coil instrument

reading 0–20 volts, with an open scale so that fractions of a volt can be read—to the D terminal on the dynamo, and connect the other lead from the meter to earth.

The regulator incorporates a thermostatic compensation which adjusts the setting of the regulator according to varying temperatures, and this must be taken into consideration when carrying out adjustments.

Adjustment must be made with the regulator cold, i.e. immediately on starting the engine, and the atmospheric temperature must be noted by means of a thermometer. Slightly increase the speed of the engine until the voltmeter needle " flicks " and then steadies. This should occur at a reading between the limits given below for the particular temperature of the regulator.

Atmospheric Temperature	*Regulator Setting*
10° C. 50° F..	8·3–8·6 volts
20° C. 68° F..	8·2–8·5 volts
30° C. 86° F..	8·1–8·4 volts
40° C. 104° F..	8·0–8·3 volts

If the voltage at which the needle reading becomes steady occurs outside the limits, the regulator must be adjusted.

Switch off the engine, release the locknut securing the adjusting screw (Fig. 1) and turn the screw in a clockwise direction to raise the setting, or in an anti-clockwise direction to lower the setting. Turn the adjustment screw a fraction of a turn and then tighten the locknut.

When adjusting, do not run the engine up to more than half-throttle, as while the dynamo is on open circuit it will build up to a high voltage if run at high speeds, which will result in a false voltmeter reading.

Cleaning Contacts

To obtain access to the regulator contacts for cleaning purposes, slacken the screws securing the plate carrying the fixed contact, Fig. 1. It will be necessary to slacken the upper screw slightly more than the lower, so that the contact plate may be swung outwards. Clean the contacts by means of fine carborundum stone or glasspaper, being sure to carefully clean away all traces of dirt or foreign matter. Finally, tighten the securing screws.

Replacement of Contacts

If the contacts are badly worn they must be renewed. Remove the armature by withdrawing the two screws which secure it to the regulator frame. Fit a new armature in position but do not tighten its securing screws. Insert a ·018-in. feeler strip between the regulator frame and the back of the armature. Press the armature firmly against the feeler, so that the back of the armature is parallel with the frame. Tighten the securing screws.

To fit a new plate carrying fixed contact, slacken off the fixing screws as described under "Cleaning Contacts," so that the old plate can be swung outward. The upper screw is now free and can be screwed into the corresponding tapped hole in the new plate. Slacken off the lower screw until the old contact plate can be withdrawn. Move the new plate into its vertical position and secure by tightening both screws (this procedure avoids displacement of the insulation and distance-piece beneath the plate).

The space between the armature and frame should be checked by inserting the feeler strip between the armature and the frame immediately behind the contacts. This gap should be within the following limits : ·016–·020 in.

If necessary, adjust the position of the fixed contact by means of thin shims ·005 in. thick, which must be fitted between the fixed contact plate and the backplate. When the armature is pressed right down, the gap between the contacts should be from ·006 in. to ·017 in.

Finally, adjust the setting of the regulator as previously described.

To Test Cut-out

If the dynamo is not charging, before assuming that the cut-out is at fault, check for possible causes of the trouble being due to the dynamo or its connections.

Short-circuit the cut-out unit by connecting the terminals marked A and D on the unit. If dynamo output is shown, it can be assumed that either the shunt or the series winding is open circuited or that the contacts need attention. In order to clean the contacts, remove the cut-out cover, place a strip of fine glasspaper between the points, close them by hand and draw the paper through. Repeat this two or three times with the rough side towards each contact.

To Adjust Cut-out

When it is found that the cutting-in speed of the dynamo is too high, connect a suitable voltmeter between the terminals marked D and E on the cut-out unit. Slowly accelerate the engine, and when the voltmeter reads approximately 6·1 to 6·5 volts the cut-out contacts should close.

If the points operate outside these limits, the gap must be reset. This adjustment is made by slackening the locknut and turning the adjusting screw a fraction of a turn, in a clockwise direction to raise the voltage and in an anti-clockwise direction to lower the voltage. Tighten the locknut after making the adjustment.

FUSES

It will be observed that there are two separate electrical circuits, each protected by its own 25-ampere fuse placed on the baseplate. A spare fuse is also provided.

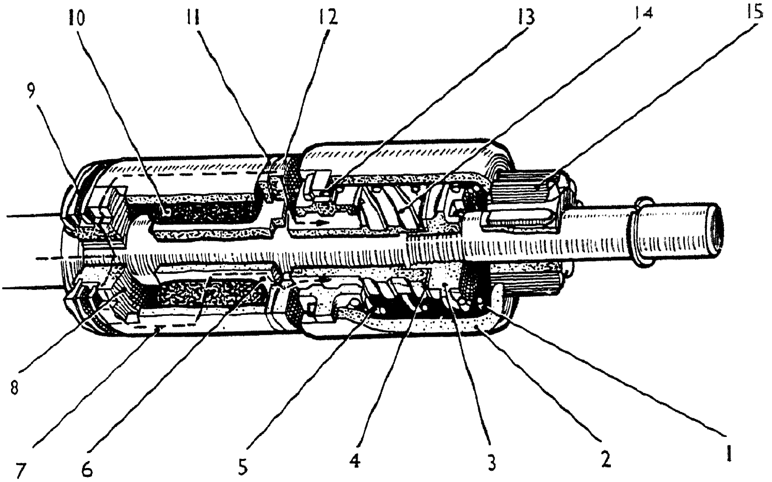


Fig. 2.—STARTER DRIVE

1. Remeshing spring. 2. Driving barrel. 3. Locating nut. 4. Thrust washer. 5. Restraining spring. 6. Inner sleeve. 7. Outer sleeve. 8. Transmission plate. 9. Relief spring. 10. Rubber coupling. 11. Friction washer. 12. Pressure and coupling plate. 13. Control unit. 14. Screwed sleeve. 15. Pinion.

STARTER MOTOR

The starter is a relatively high-speed motor, with a drive which consists essentially of a pinion which engages with a toothed ring on the flywheel of the engine.

The type of drive fitted to this starter embodies a combination of a rubber torsion member and a friction clutch, in order to control the torque transmitted from the starter to the flywheel, and to dissipate the energy in the rotating armature of the starter at the moment when the pinion engages the flywheel. It also embodies an overload release mechanism which functions in the event of a very heavy backfire, or if the starter is inadvertently meshed into a flywheel rotating in the reverse direction.

The drive from the starter shaft is transmitted in the first instance through a key into the transmission plate, which is engaged in slots in the outer member of the rubber coupling. Between this outer member and the central tube is mounted a rubber torsion bush, which is so assembled as to press tightly against the inner surface of the outer member and the outer diameter of the central tube. At the end of the central sleeve are two projections which engage with slots in the coupling plate. This plate has, in addition, a further pair of slots into which locate corresponding projections on the screwed sleeve. On the screwed sleeve is mounted the control nut, to which is coupled the barrel carrying the pinion.

When the starter switch is operated, the rotation of the armature and the pressure of the remeshing spring causes the control nut to engage with the thread on the screwed sleeve. The control nut and barrel carrying the pinion move along the screwed sleeve until the pinion meshes with the flywheel teeth. Should the teeth of the pinion meet the flywheel teeth end to end, the relief spring absorbs the shock and enables the pinion to edge its way into mesh.

When the pinion is fully in mesh with the flywheel, the drive from the shaft to the pinion is taken by two paths—one via the transmission plate to the outer member of the rubber coupling and through the friction washer to the screwed sleeve, while the other is via the transmission plate from the outer to the inner sleeve through the rubber bush and then directly to the screwed sleeve.

An important feature of this type of drive is that it provides an effective safeguard against such an overload as may be caused by a backfiring or backrunning engine. Under normal loading the drive is taken through the rubber coupling without any slip occurring. Under conditions of overload, a considerable proportion of the load is absorbed by the rubber, which becomes torsionally deflected. In an extreme case of overload it is possible for slip to occur momentarily between the rubber and the sleeve on which it is mounted, thereby relieving the drive from the effect of the overload.

To Remove Starter Motor

Disconnect the switch lead. Withdraw the bolts securing the starter to the flywheel housing and the starter rear support to the crankcase, when the assembly can be lifted away.

If the starter is dismantled, inspect the friction washer and renew if necessary. Check also the rubber coupling for wear. See that the control nut is free on the screwed sleeve. If the pinion restraining or remeshing springs appear to be weak or are broken, these should be renewed. Check the fit of the drive shaft in the commutator endplate bearing and the drive housing bearing, and renew as necessary. When reassembling ensure that the parts are fitted in the order shown in Fig. 2.

SPARKING PLUGS

On the 10-h.p. engine A.C.—K.9.V., side electrode plugs are used, gap, ·037 in. to ·040 in.

When setting the gap, the side electrode only should be bent.

Two types of plugs have been used on the 25-h.p. engine: A.C.-K.9, side electrode with ·027 in. to ·030 in. gap, and A.C.-K.11, end electrode with gap ·038 in. to ·040 in.; at engine No. G.2592 the K.11 was made standard. Unless it is necessary to renew the whole set, in which case the K.11 should be fitted, make renewals with the type corresponding to that already in use on the engine.

To Remove Distributor

Remove the distributor cover by springing aside the two retaining clips. Disconnect the low-tension lead from the baseplate terminal post which protrudes through the body.

Rotate the engine and watch the opening in the right-hand side of the clutch housing until a bright steel ball embedded in the flywheel is seen to be opposite to the pointer with the rotor pointing to the position corresponding to the No. 1 cylinder electrode.

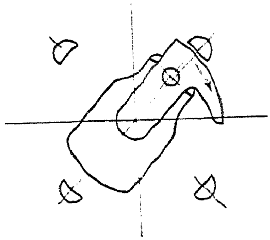


Fig. 3.—DISTRIBUTOR ROTOR CORRECT POSITION

The relative position of the electrode in the cover corresponding to No. 1 cylinder should be noted.

Remove the two nuts securing the distributor to the crankcase boss, and slacken the clamp bolt holding the vacuum control arm to the distributor body.

Withdraw the distributor assembly from the crankcase.

To Replace and Retime Distributor

If the engine has been rotated since the distributor was removed, it must be turned so that the steel ball is opposite to the pointer with No. 1 piston at the end of the compression stroke, which can be ascertained by observing when both the inlet and exhaust valves are closed.

Turn the distributor rotor to the position which corresponds to the No. 1 cylinder electrode in the cover.

Note the position of the slot in the end of the distributor shaft, and line up the dog at the top of the pump spindle to correspond. This can be turned by using a long screwdriver inserted down the boss in the crankcase; when positioning, allowance must be made for the angular movement of the distributor shaft whilst the helical gear is meshing with the gear on the camshaft.

Slide the distributor into the boss holding the rotor in the correct position. Connect the low-tension lead. Set the micrometer adjustment of the vacuum control to "Zero."

Rotate the distributor body until the points just commence to open, and tighten the clamp. Replace the distributor cover. Finally, check the timing, using Matrascope timing lamp Britool No. 909/909A. Remove the sparking-plug lead and the small brass adaptor from No. 1 sparking plug. Fit the special adaptor supplied with the lamp and replace the plug lead, then clip on one of the timing-lamp leads, earthing the other. Start the engine and adjust the throttle stop-screw on the carburettor until the engine is running slowly.

Fix the timing-lamp reflecting "mirror" close to the inspection hole in the flywheel housing, and when the neon tube flashes, the steel ball should be visible on the chromium "mirror."

If the timing is correct, the reflection of the light from the steel ball will occur exactly under the pointer, appearing as though the ball were stationary.

Any error in the setting will be shown by the ball appearing to rest at one side or the other of the pointer, and this can easily be rectified by loosening the distributor clamp and slowly turning the body one way or the other. Rotate the body in a clockwise direction if the ball has passed the pointer at the time of the flash.

After the retiming operation is satisfactorily completed, adjust the carburettor throttle stop-screw to prevent the possibility of the engine stalling under driving conditions. The micrometer adjustment of the distributor must not be used in the initial setting of the ignition timing. It is provided solely for the purpose of altering the basic setting to meet the requirements of the grade of petrol used, and any such adjustment should be made on the road.

Cases are sometimes found, however, where " tracking " of the moulding has occurred. Tracking is a form of burning which takes place between the distributor rotating electrode and the moulding electrode and takes the form of a thin black line in the moulding.

A replacement moulding must be fitted in the place of the one that is tracked.

Tracking can usually be traced to large sparking-plug gaps, excessive wear on the distributor rotor, or incorrect ignition timing.

If the distributor cover and rotor have been dismantled for inspection, after replacing the rotor, check the timing by removing the distributor moulding and substituting a moulding which has been cut away so as to show the position of the rotor to the electrodes.

The correct position for the rotor when the contact breaker just commences to open is shown in Fig. 3.

The contact-breaker gap should be ·010/·012 in.

The distributor shaft should be a free sliding fit without perceptible play. The maximum permissible end float on the shaft is ·003 in., and if in excess, check for wear on the gear, the bracket, the fibre washer under the advance mechanism base plate, and also the gear thrust washer. The end float is very important, as it affects the quietness of the distributor and also the life of the rotor and cover electrodes.

Renew any parts which may seem to be worn, and if this does not reduce sufficiently the end float, check for wear on the top and bottom faces of the body.

A simple remedy if wear has taken place on these faces is to insert shims of requisite thickness between the bracket and the bottom face of the body.

Wiring Connectors

To facilitate removal of various sections of the wiring harness, detachable connectors of plug-and-socket type, consisting of brass sleeves sur-

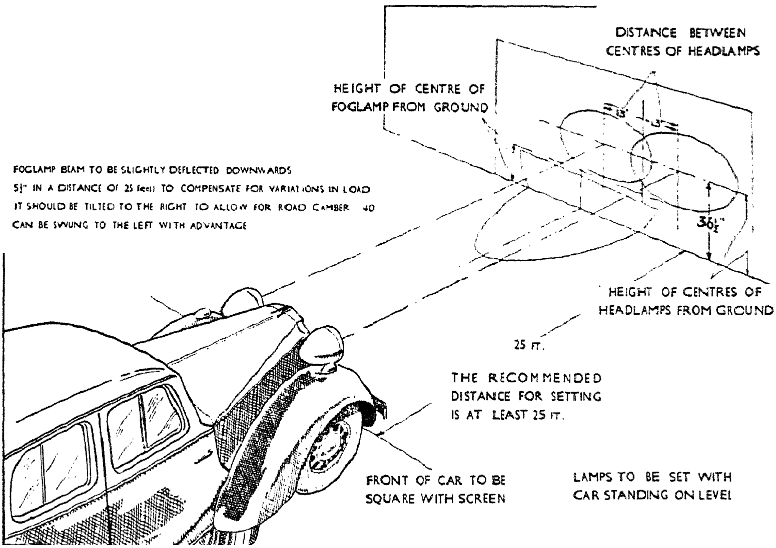


Fig. 4.—LAMP-ALIGNMENT DIAGRAM (10 H.P.)

rounded by rubber, are used. As it is rather difficult to insert the plugs on the end of the cables into the connectors, a special tool has been developed for this operation, namely, Britool Easy Connector Pliers No. 924, the use of which prevents any damage to the wires themselves.

To Align and Focus the Headlamps

On the wall or a board scribe a horizontal line 36½ in. from the ground, and then two vertical lines 26 in. apart (Fig. 4). The car must be placed facing this marking at a minimum distance of 25 ft. (7·5 m.), with the headlamps straight in line with the vertical markings. To make an exact test the locality should be in absolute darkness, and when the headlamps are switched on the brightest beams of light should appear on the wall as two elliptical areas with the points where the lines cross as the centres. Equality of intenseness of the beams should be checked by covering up the headlamps in turn and comparing the effect.

Line up the headlamps so that they are in the same plane. Switch on the lights and adjust each headlamp so that the centre of its beam coincides with the point where the horizontal line crosses the corresponding vertical line.

To make adjustments, release the spring clip at the bottom of the rim and remove the front of the lamp. The headlamp bulb can be fitted in

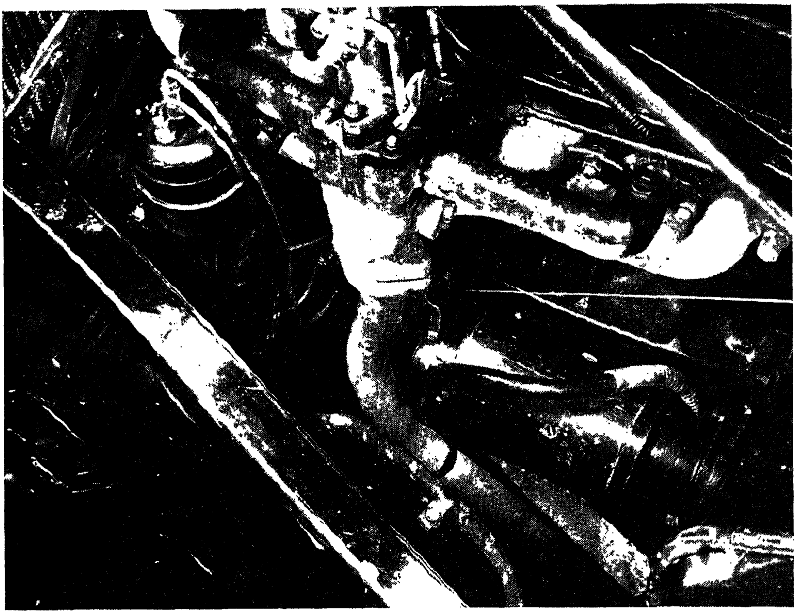


Fig. 5.—General view of nearside of motor, showing position of dynamo and starter on 1938 Vauxhall 14

(*By courtesy of Shaw & Kilburn*)

three different positions for focusing purposes, and the bulb should be inserted in the position which gives the most suitable result.

Make certain that the bulbs are in good condition. Correct illumination cannot be obtained with a blackened bulb. A dirty reflector will reduce the amount of light given by the lamps, and should be cleaned by wiping with a very soft cloth or chamois leather. Do not use metal polishes.

LIGHT SIX, 12-H.P. AND 14-H.P. CARS (MODELS D)

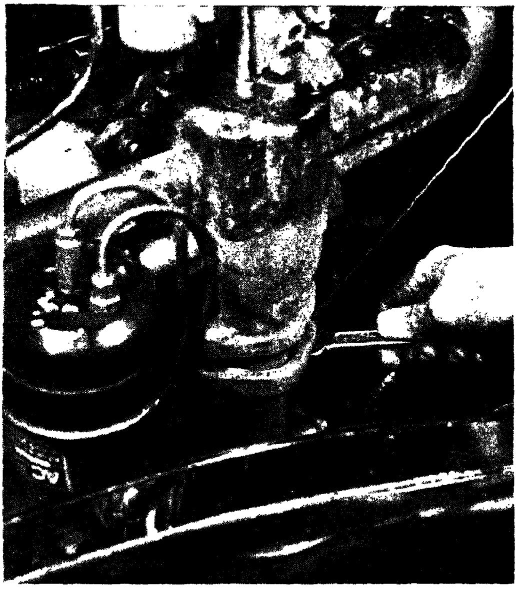
To Adjust Dynamo Output

The output of the dynamo is controlled by the relative position of the control brush to that of the main brushes. To alter the output, slacken the hexagon-headed screw and apply a light pressure on the brush holder, tending to rotate it. This applies to models before Chassis Nos. DX. 655401 and DY. 514001.

Commencing with these chassis numbers, the control brush holder is held by friction only, so that a light push is sufficient to make the necessary adjustments.

Fig. 6.—(*right*) REMOVING EXHAUST FLANGE AND RELEASING EXHAUST PIPE TO FACILITATE REMOVAL OF STARTER

Note.—Graphite the threads of bolts to prevent rusting up. (*By courtesy of Shaw & Kilburn*)



Moving the control brush round in the same direction as the armature revolves when the engine is running increases the output, and moving it in the opposite direction reduces it. The adjustment is a sensitive one and, therefore, a very small movement is sufficient to affect the output considerably.

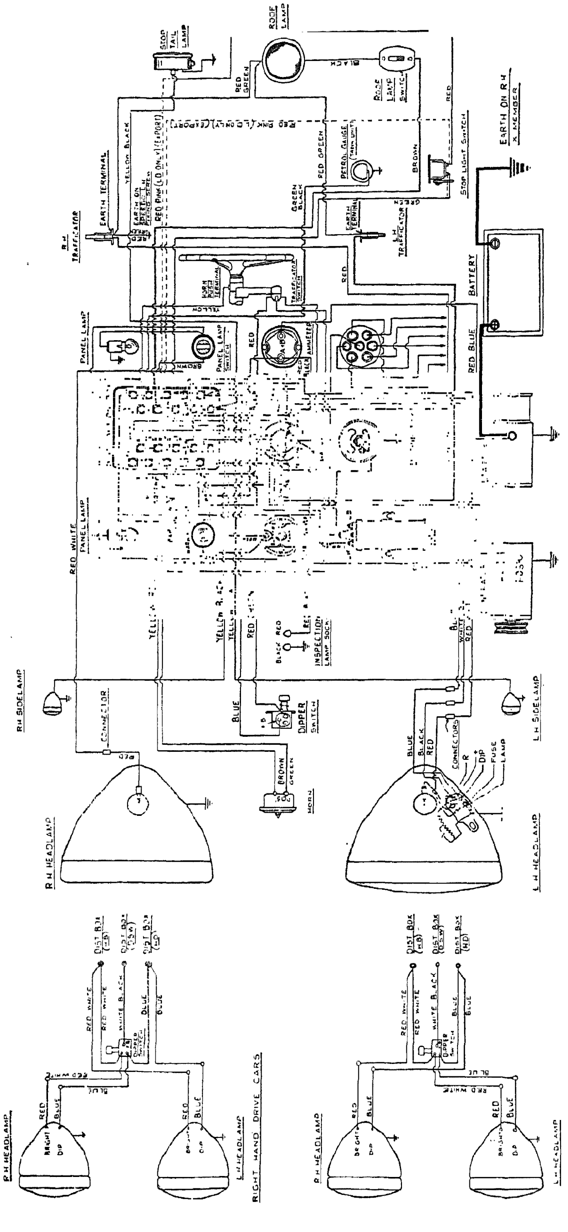
The correct setting when the dynamo is warm, and with the lighting switch in the winter or "high" position, is between 6 to 8 amperes at 25 m.p.h. in top gear.

Distributor

Reference to Fig. 10 shows the relationship of the distributor to the camshaft and oil pump, and it will be noted that tapered grub-screws are employed for securing both the pump and distributor to the crankcase.

Fig. 7. (*right*).—REMOVAL OF STARTER AFTER REMOVING STARTER SWITCH AND CABLE

(*By courtesy of Shaw & Kilburn*)



To replace and retime Distributor

Remove the Bakelite cap from the distributor to be refitted and turn the rotor towards No. 1 high-tension lead, remembering that the low-tension terminal must face toward the right-hand side of the chassis.

Hold the rotor in the determined position in relation to the distributor body and note the position of the slot formed below the driving gear.

This slot must line up with the dogs formed at the top of the oil-pump spindle, since the latter is driven in tandem from the distributor gear.

By looking down the bore of the boss on the side of the crankcase into which the distributor is to be fitted the top of the oil-pump spindle can be viewed, and with the aid of a long, thin screwdriver the dogs can be turned to line up with the slot on the distributor gear. Allowance must be made for the angular movement imparted to the distributor spindle by meshing up the helical gear with that of the camshaft.

Slide the distributor into the bore of the crankcase, as far as possible, holding the rotor opposite No. 1 high-tension lead, and if the oil-pump dogs have engaged correctly with the slots of the distributor gear, the tapered groove in the bronze thrust ring, immediately above the gear, will be in line with the grub-screw hole in the crankcase.

This can be checked by using a small mirror held at an angle to look up the grub-screw hole, when the tapered groove should be clearly visible.

In the event of the groove being out of line, it indicates that the oil-pump drive has not been correctly engaged, and the distributor must be withdrawn so that the pump spindle can be moved slightly to allow correct engagement.

When this is achieved, insert the grub-screw, taking care not to use force, and lock in position with the nut provided. Connect the low-tension lead to the terminal on the side of the distributor.

Set the micrometer adjustment so that the line on the connecting rod is opposite the zero mark on the scale and move the distributor body as required until the points are just breaking, then tighten the clamp bolt. Replace the distributor cap.

A neon tube should be employed for finally checking the timing as described in connection with the 10-Four.

Distributor Cover and Rotor

Cases are sometimes found where burning early in the life of a vehicle takes place on the leading side of the cover contacts, and this indicates lack of adjustment. Burning after heavy mileages is, of course, a matter of normal wear and merely calls for renewal of the cover.

The simplest and most accurate method of discovering the cause in the former case is to make use of an old cover, the top of which has been cut away with a hacksaw so as to leave the cover electrodes in position but to expose the interior of the distributor.

It is then an easy matter to check the difference in the gaps between

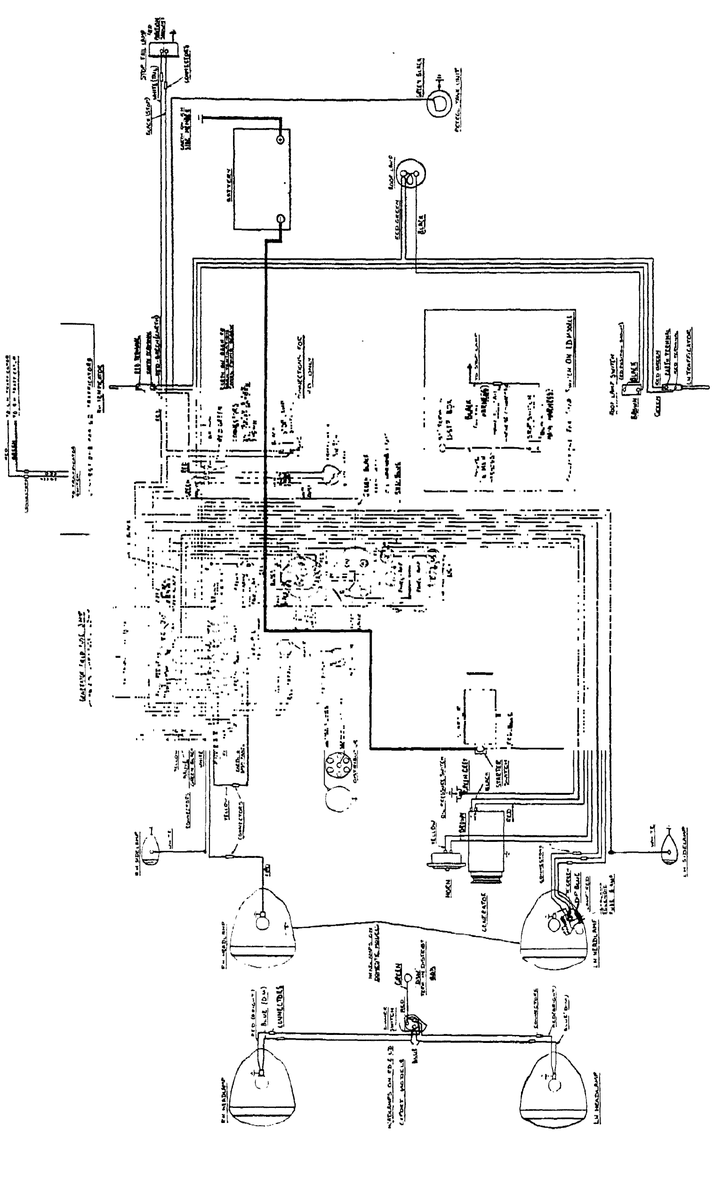


Fig. 9.—WIRING DIAGRAM, VAUXHALL "LIGHT SIX," 12 AND 14 H.P.—FROM CHASSIS NOS. DX. 655401 AND DY. 51400

the rotor point and the cover electrodes measured in a vertical direction and in a horizontal direction. The horizontal gap is much smaller than the vertical gap, in order to ensure that the spark jumps from the rotor to the end of the cover contact and not to the portion nearest the moulding.

If the reverse is found to be the case, check the distributor shaft for end float, bearing in mind, of course, that the rotor is pushed home on its spindle.

In this connection an important point to watch is the setting of the contact-breaker points. It will be appreciated that if the points are set too wide the spark will occur in an advanced position, and if this is the case the horizontal gap at that time may be greater than the vertical gap, which will result in burning of the moulding. The overlap between the rotor point and the cover contacts should be at least $\frac{1}{16}$ in. when the spark occurs (or when the points begin to open).

Examine the rotor point, and if it is found to be burned away on the leading edge it must be changed.

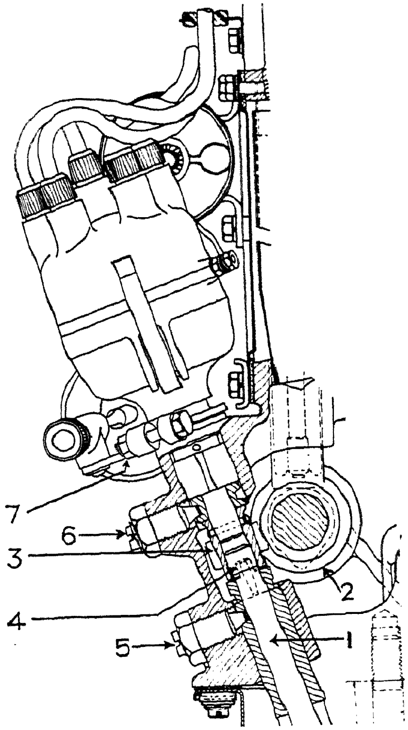


Fig. 10.—DISTRIBUTOR ATTACHMENT TO CRANK-CASE

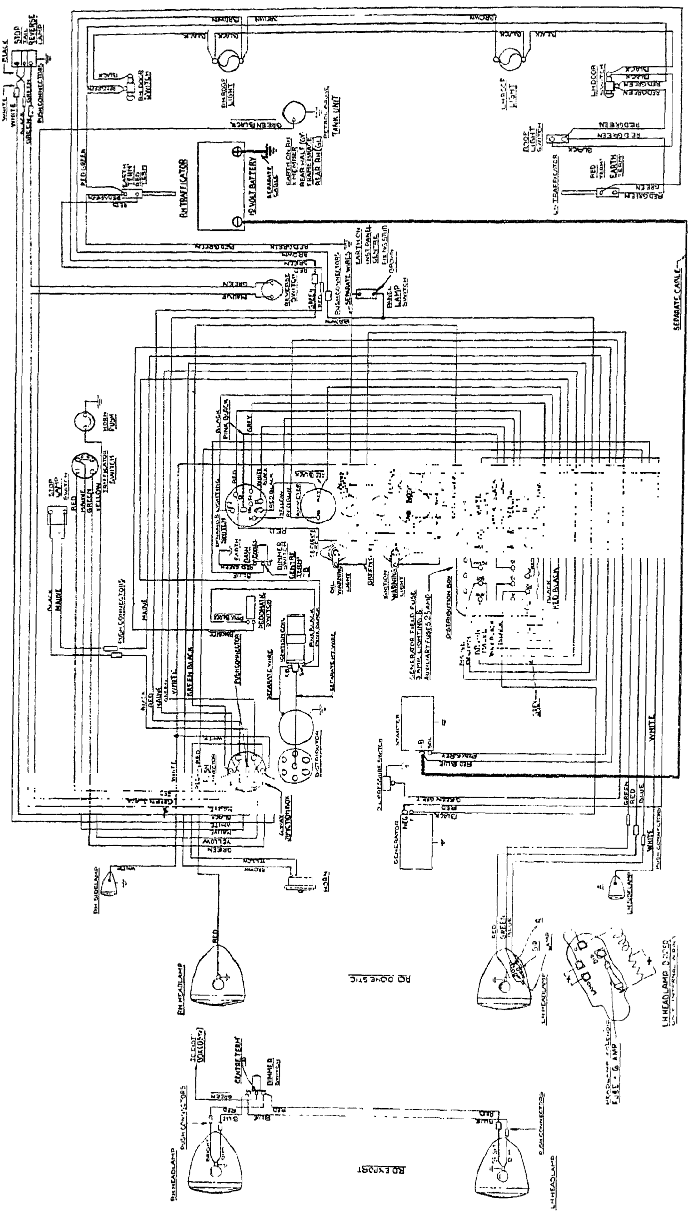
1. Oil-pump spindle. 2. Camshaft gear. 3. Distributor gear. 4. Oil-pump driving dogs. 5. Oil-pump location grub-screw. 6. Distributor-spindle location grub-screw. 7. Advance and retard collar clamp bolt.

Side play in the rotor arm may cause burning of the cover contacts, and it is therefore advisable to make sure also that this is a good fit on the spindle.

Another point of importance in connection with the cover is the condition of its central brush and spring ; if the brush is excessively worn or its spring is weak or broken, it must be renewed.

Distributor Shaft

The end float of the shaft should not be in excess of ·010 in. The remedy is as described for the 10-h.p. shaft.



25-H.P. MODEL G

The output of the dynamo is controlled by the third brush in the same way as described in connection with the "Light Six" model. Removal of dynamo, and dismantling, and assembly are similar to the 10-h.p. car.

Pedomatic Starting Equipment

Full depression of the clutch pedal operates an intermediate switch or pedomatic unit, which in turn actuates the solenoid switch on the starter motor. The pedomatic switch incorporates a small clutch plate which is maintained in contact with a plunger by a small spring. The plunger is connected to a diaphragm which is under vacuum control from the inlet manifold.

On depressing the clutch pedal, the pedomatic-switch clutch plate is rotated and contact is made, enabling current to flow and operate the starter solenoid switch. As soon as the engine fires, however, induction vacuum withdraws the diaphragm, and with it the plunger, thus breaking the contact and disengaging the switch mechanism during the time the engine is running.

To remove the pedomatic unit, disconnect the battery lead, and then the two electric cables from the switch. Unscrew the pipe union from the diaphragm unit. Release the wire from the operating arm. Remove the bolts attaching the switch unit to the support held to the brake master cylinder.

After releasing the suction unit from the body of the switch, by removing the fixing nuts and washers, inspect the contacts and if necessary clean with fine emery cloth, taking care not to distort them.

Examine the switch setting. With the rotor in the off position, the moving contact must rest lightly on the moulded rotor heel. In this position, the gap between the contacts must not be less than ·030 in. Push the rotor into engagement and turn it to close the switch contacts. The angle through which the rotor moves before closing the switch contacts should be 5° to 10°. If necessary, bend the switch contacts in order to obtain the above setting.

Lubricate the switch mechanism by lightly smearing the heel and other moving parts with thin machine-oil. Reverse the operations given for removal. Whenever clutch-pedal adjustment is carried out, it is necessary to check or readjust the switch-control wire. This is attached to the lower end of the pedal, and it should be free from slack when the pedal is depressed 4½ in.

The Cut-out Adjustment

Testing for faulty cut-out is the same as already described for the 10-h.p. When it is found that the cutting-in speed of the dynamo is too high, connect a suitable voltmeter between the terminals marked D and E on the cut-out unit. Slowly accelerate the engine, and when the voltmeter reads approximately 14 volts the cut-out contacts should close.

If the points operate outside these limits, the gap must be reset. This adjustment is made by bending the stop plate, and to lower the operating voltage the air gap must be reduced and vice versa. As the adjustment is very sensitive, great care must be taken to alter the setting by only a small amount.

Fuses

It will be seen that there are five circuits, each protected by a fuse. The horizontally placed fuses are all 25 amperes, and grouped together below these fuse holders will be found spare 25-ampere fuses.

The dynamo circuit is protected by the 6-ampere fuse placed vertically on the baseplate. Spare fuses for this circuit are clipped to the inside of the bakelite cover.

Distributor

To replace and retime distributor, follow instructions already given for the "Light Six."

The distributor shaft end float should not exceed ·010 in., and the same remarks apply as in the case of the 10-h.p. model.

To Align and Focus the Headlamps

Referring to Fig. 4, which applies to lamp alignment of the 10-h.p., the measurements for the 25-h.p. model are: horizontal line 39 in. from the ground, and vertical lines 31½ in. apart. The car must be placed facing this marking at a minimum distance 25 ft.

To make adjustments, release the spring clip at the bottom of the rim and remove the front of the lamp. Draw out the reflector and slacken the clamp at the back of the bulb holder. This enables the bulb holder to be moved forwards or backwards until the best possible beam is obtained.

The electrical equipment on 12-Four Vauxhall Cars is similar to that on the 10-h.p. model described. The notes on the "Light-Six," 12-h.p. and 14-h.p. refer to model "D."

The electrical equipment on the 14-h.p. "J" model are dealt with in a later article.

DELCO-REMY DYNAMOS AND CONTROL UNITS

DELCO-REMY dynamos and the associated control equipment, such as cut-outs and regulators, are met with on cars of American origin.

THIRD-BRUSH DYNAMOS

We shall deal first with the third-brush types of dynamo, which may be divided into two general classes :

(*a*) Output regulated by third brush.

(*b*) Output regulated by third brush and an external voltage regulator.

The third-brush method of regulating the current output is used because of its simplicity of operation and adjustment. It meets the average driving requirements as it produces the maximum generator output at normal driving speeds. When the generator is cold, the output will be somewhat higher than after it becomes warm. Also, at speeds beyond the maximum-output range, the output will be reduced or will taper off, due to the normal action of the third brush.

Types of Field-circuit Control

The third-brush dynamos used may be classified according to the manner in which the field circuit is controlled, as follows :

No. 1. Field circuit earthed directly to dynamo frame. (No control except third-brush regulation.)

No. 2. Step-voltage control. (Automatically controlled field resistance.)

No. 3. Lamp-load control.

No. 4. Vibrating voltage regulator. (Automatically controlled field resistance.)

No. 5. Manually controlled field resistance.

No. 6. Divided field circuit.

No. 7. Thermostat controlled field resistance.

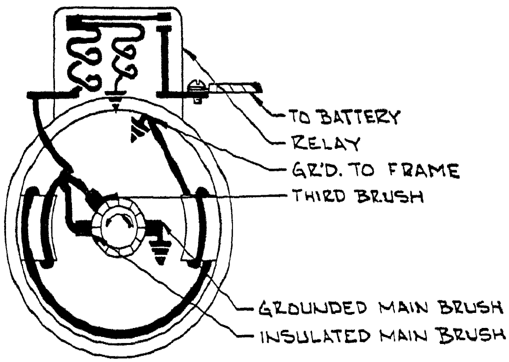


Fig. 1.—THIRD-BRUSH REGULATED DYNAMO ONLY

There is no control except third-brush regulation. The field circuit is earthed or grounded directly to generator frame.

THIRD-BRUSH REGULATION ONLY

Adjusting Output of Dynamo

With dynamos having only third-brush regulation, the field circuit is connected directly to the frame of the dynamo, and it is necessary to shift the third brush to vary the output in accordance with driving requirements and the condition of charge of the battery. With this type of regulation there is a tendency for the charging rate to increase as the battery becomes fully charged. This is caused by the rise in the terminal voltage of the battery as it becomes fully charged. Any rise in battery voltage causes an increase in generator voltage, thus increasing the current in the field coils. When the field-coil current is increased, the output of the generator is increased by a proportionate amount.

STEP-VOLTAGE CONTROL

The third-brush type of generator without some means of automatic voltage control has a tendency to further increase its maximum output as the battery approaches a fully charged condition. This condition may result in an overcharged battery and high voltage within the electrical system.

Operation of Step-voltage Control

The purpose of the step-voltage control unit is to increase or decrease the generator output in accordance with the requirements of the battery and the connected electrical load. When the battery becomes properly charged, a set of control points in the control unit opens and shunts the generator field circuit through a resistance unit to earth. With the resistance unit in the field circuit, the generator maximum output is reduced to a safe value. The generator will continue to charge at the lower rate as long as the battery is fully charged and the electrical load is small. If the battery should become partially discharged, the contact points in the control unit close, removing the resistance from the field circuit, and the generator output increases to its maximum, depending upon the setting of the third brush.

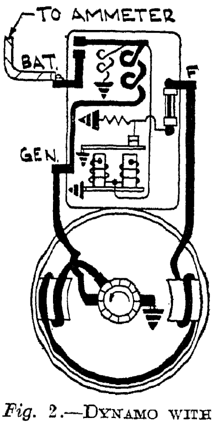


Fig. 2.—DYNAMO WITH STEP VOLTAGE CONT OL

When a sufficient electrical load is connected, such as lights, radio, heater, etc., to require a higher generator output, the voltage-control contact points will be closed and the generator will produce its maximum output, depending upon the position of the third brush, and carry the added load without drawing current from the battery. The voltage-control unit does not increase the maximum output of the generator, as this is

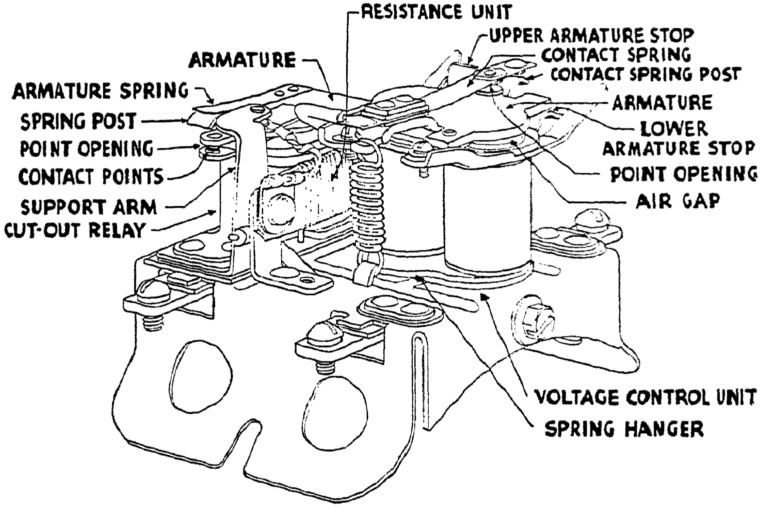


Fig. 3.—STEP VOLTAGE CONTROL UNIT

dependent entirely upon the design of the generator and the third brush. Where driving is confined to daytime operation and there is no connected load (except ignition) the generator output may be too high. The output should then be reduced by adjusting the third brush to meet driving requirements. The voltage-control unit will then reduce the output to a safe value when the battery becomes fully charged.

The step-voltage control, mounted either on the engine side of the dash or on the generator, operates to decrease the maximum generator output when the battery reaches a fully charged condition.

Procedure for Checking Step-voltage Control Unit

For typical specifications of step-voltage units, *see* table later.

Check the voltage at which the contact points of the cut-out relay close and the reverse current opening with the ammeter and voltmeter connected as illustrated in Fig. 4. Increase and decrease engine speed slowly in order to obtain accurate meter readings at the instant the points open and close.

If the relay does not perform according to specifications, adjust according to the methods described under Adjustments of Cut-out Relay.

Connect the ammeter and voltmeter according to Fig. 5 to check the output of the generator. To secure the maximum output of the generator, it is necessary temporarily to earth the generator field. This is accomplished by disconnecting the lead from the " F " terminal of the regulator and touching it to the base of the unit. Earthing the generator field

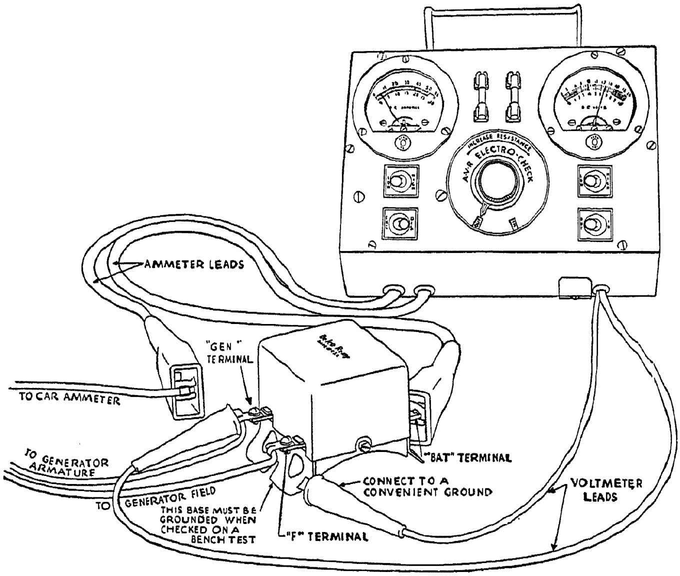


Fig. 4.—CHECKING STEP VOLTAGE CONTROL UNIT

Showing ammeter connections for checking the reverse current opening of the cut-out. Voltmeter connections are for checking the cut-out closing voltage.

prevents the control unit from operating and influencing the generator output. It must be borne in mind that the generator output is automatically reduced when the voltage-control unit is operating.

To check the opening and closing voltage of the voltage-control unit, use the same ammeter and voltmeter connections as in Fig. 5. (Control-unit cover must be in place when checking opening and closing voltages.) Gradually increase engine speed and note the voltage at which the contact points of the voltage-control unit open and close. When the points open the output is reduced, and when they close the output increases.

If the battery is in a low state of charge, the voltage will not be sufficient to cause the control unit to operate, and the contact points will normally be held closed. To secure the voltage necessary to operate the control unit, throw the resistance switch (if fitted to the tester) to the in position. Then slowly increase the resistance until the points close. This is the closing voltage of the voltage-control unit. Slowly decrease the resistance until the points open. This is the opening voltage.

If a tester is not available, it may be necessary to insert a small variable resistance (approximately ·25 ohm maximum) into the charging circuit at the "Bat" terminal, between the control unit and the battery.

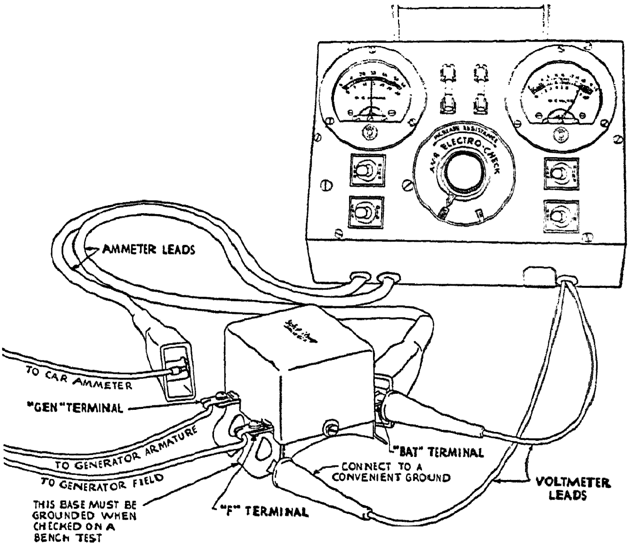


Fig. 5.—CHECKING DYNAMO OUTPUT AND STEP VOLTAGE CONTROL UNIT

Showing ammeter and voltmeter connections for checking and adjusting the dynamo output. Use the same connections in checking the opening and closing voltages of the step control unit.

The lowest possible resistance to obtain the proper voltage should be used to prevent the contact points vibrating.

Conditions Affecting Voltage-control Performance

(1) A low generator output with a fully charged battery indicates that the generator and voltage-control unit are functioning according to specifications.

(2) A low output with a partially discharged battery indicates that the generator and regulator are not functioning properly.

(3) If trouble appears to be in the generator or the voltage-control unit, the terminal marked " F " may be temporarily earthed to determine if the generator or the control unit is at fault. If the generator charges at its specified rate with the " F " terminal grounded, the control unit is probably at fault and should be removed for checking. When the " F " terminal is earthed and the generator does not perform according to specifications, it indicates that the generator is at fault. Check for high generator voltage.

(4) A loose connection or high resistance in the charging circuit between the control unit and the battery will cause the voltage-control points to operate at times and reduce the generator output even though

the battery may not be fully charged. A high resistance or loose connection will sometimes cause the points to vibrate.

(5) In cases where the generator charging rate is too high or too low for the driving requirements, check the opening and closing voltages of the voltage-control unit. If the control unit checks according to test specifications, adjust the third brush of the generator in the proper direction to increase or decrease the output. (Refer to specifications.) The voltage settings must be maintained within the specifications for the particular unit.

Cleaning Contact Points

Contact points should be cleaned with a thin, fine-cut contact file. The contact file should not be used to file other metals. The contact points can be cleaned without disturbing the regulator setting, if care is taken to avoid bending the contact spring excessively.

Caution.—Do not use file excessively on contact points. Never use sandpaper or emery cloth to clean contact points.

Adjustments—Voltage-control Unit (Fig. 3)

The spring tension, measured at the contacts with the armature up, should be approximately $\frac{3}{4}$ oz. at the instant the points separate. Adjust the spring tension by bending the contact spring.

Air Gap

Hold the armature down against the lower armature stop and set the air gap between the centre of the core and armature by bending the lower armature stop.

Armature Travel

Release the armature and gauge the travel between the armature and the lower armature stop. This amount of travel is obtained by bending the upper armature stop backward or forward.

Point Opening

With the armature held down against the lower armature stop, measure the contact-point opening. The point opening may be adjusted by bending the contact-spring post.

Voltage Setting

Check the opening and closing voltage of the control unit as previously described (refer to Fig. 5). Run the generator until the control unit becomes warm. Retard the engine or generator speed until the cut-out relay contact points open, then increase speed until contact points close

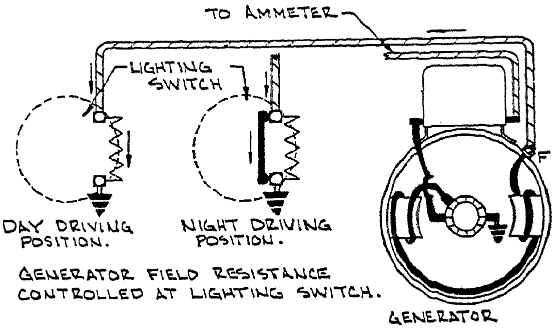


Fig. 6.—LAMP LOAD CONTROL

Showing generator field resistance controlled at lighting switch.

before checking voltage readings. Do not overrun the opening and closing voltages, as the voltage readings must be taken at the instant the points open and close. Voltage readings must be taken with the control-unit cover in place to obtain true values.

The opening voltage can be increased by increasing the spring tension of the spiral spring. This adjustment is made by bending the hanger to which the lower end of the spiral spring is attached. Decreasing the spring tension lowers the opening voltage.

The closing voltage is increased by increasing the air gap between the armature and core or decreased by decreasing the air gap. It is only necessary to bend the lower armature stop slightly when adjusting the closing voltage.

(*Note.*—After this adjustment, it may be necessary to readjust contact-spring post to maintain the correct contact-point opening.)

LAMP-LOAD CONTROL

Lighting Switch-controlled Field-resistance Type

With the type of lamp-load control generator, a resistance (mounted on the back of the lighting switch) is in series with the generator field circuit, when the lighting switch is in the " off " position, against the dash. With the resistance in the field circuit, the generator output is reduced. When the lights are turned on for night driving, or when the radio is being used, the resistance is cut out of the generator field circuit by a direct earth at the switch. Consequently a higher generator output is then available. The higher output for daytime driving can also be obtained on some cars by pulling the light switch to the first position, without turning the lights on, to cut the resistance out of the circuit.

Changing Output of Dynamo

The current output is adjusted by shifting the third brush. In order to obtain the maximum specified output of the dynamo, the resistance

unit should be cut out of the field circuit. This can be quickly accomplished by earthing the field terminal on the generator frame (designated "F" in Fig. 6). A 1-ohm resistance unit is standard on these switches. However, other units are available for various types of driving conditions in $\frac{1}{2}$-, $\frac{3}{4}$-, and $1\frac{1}{2}$-ohm sizes. The 1-ohm resistance is suitable for average driving, which consists of day and night driving as well as high-speed and low-speed driving. An excessive amount of any one particular type of operation will warrant changing to another size resistance. Without disturbing the third-brush setting, the generator output for day driving can be increased by decreasing the size of the resistance unit; likewise, the output can be decreased by increasing the size of the resistance unit. Where trouble is experienced with discharged batteries, due to excessive night driving, a $\frac{1}{2}$- or $\frac{3}{4}$-ohm resistance should be used. If daytime operation results in an overcharged battery condition, the $1\frac{1}{2}$-ohm unit will reduce the charging rate. In some cases of overcharged batteries, it may be advisable to shift the third brush to reduce the output in addition to using a larger resistance unit.

Faulty Resistance

If the generator does not charge when the lights are off but charges when the lights are on, it indicates that the resistance unit is open-circuited, and it should be replaced.

VIBRATING VOLTAGE REGULATOR

Dynamos used with this type of regulator have the third brush in a fixed or adjustable position. The operation of this regulator is similar to the step-voltage control unit except that the contact points in the regulator vibrate many times per second and regulate the output automatically in accordance with the state of charge of the battery and the connected electrical load. This type of regulator will not increase the output of a generator, as this is dependent upon the original design of the generator and the location of the third brush. It will, however, control the output of the generator by automatically decreasing the charging rate to a low safe value when the battery approaches a fully charged condition. When the lights or other electrical loads are turned on, the charging rate will increase to take care of the load, up to the maximum rated output of the generator, if necessary.

Operation

The Delco-Remy vibrating voltage regulators consist of a conventional cut-out relay and a vibrating voltage-regulator unit. Fig. 7 illustrates the connections of an "IGN" terminal type. In a no-"IGN"-terminal-type regulator, the regulator voltage winding is connected to the cut-out

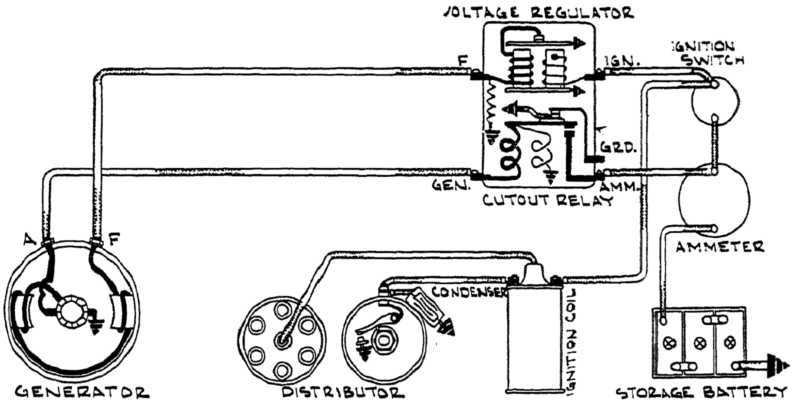


Fig. 7.—VIBRATING VOLTAGE REGULATOR UNIT AND ITS CONNECTIONS

frame instead of to an "IGN" terminal. Some units, as in Fig. 7, have an auxiliary terminal marked "GRD" and an auxiliary set of contact points on the cut-out armature through which the starting motor solenoid relay completes its circuit. A generator charging indicator light, used in place of a dash ammeter, may also be connected to this set of contacts, in which case they will be insulated from the armature. These points are not part of the charging circuit.

The voltage-regulator unit consists of two cores which, with their windings, form an electro-magnet. One core is wound with numerous turns of fine wire and is connected to the "off" side of the ignition switch, as illustrated in Fig. 7. As the battery voltage increases to a predetermined value, the magnetic pull on the regulator armature increases until the armature is attracted towards the core, against a restraining spring tension. A pair of contacts in series with the generator field are opened, and a resistance shunting these contacts is inserted in the field circuit. This resistance is sufficient to reduce the generator voltage below that necessary to open the contacts, and they immediately close, eliminating the resistance, thus increasing the voltage of the generator. This cycle occurs many times per second, resulting in a battery voltage that is held practically constant.

The second core is wound with a few turns of larger wire in series with the generator field, and aids the main winding of the regulator unit. When the contacts break, the current in this circuit is instantly reduced, and likewise the magnetic pull on the armature, thus allowing quicker closing of the contacts and more rapid vibration of the armature.

The regulators are over-compensated for temperature so that they have a lower voltage when hot. This compensation for temperature is

necessary, as a cold battery requires a higher charging voltage than one that is warm, consequently it is necessary to vary the charging voltage in accordance with battery requirements.

The compensation is accomplished by the use of a bi-metal hinge on the regulator armature. It is not necessary to change the voltage setting for winter and summer driving.

Installation Caution

Check the mounting of the regulator unit to determine if a good earth connection is being obtained. Regulators are designed for use with negative and positive earthed batteries. A regulator designed for use with a positive earth must be used with a battery having the positive terminal earthed, and a regulator for negative earth must be used with a negative-earthed battery.

If the polarity of the generator is reversed, the cut-out relay contact points will vibrate and burn. To avoid the possibility of reversing the generator polarity, the regulator should be mounted on the dash before connecting the leads to the regulator. In connecting the leads, the " F " terminal connection at the regulator should be made *last*. To eliminate any doubt as to the polarity of the generator, momentarily connect a lead from the " GEN " to the " BAT " terminals of the regulator *after* all the connections have been made and *before* the engine is started. This will automatically give the generator the correct polarity.

Rough Check to Determine Location of Trouble

If the generator and regulator do not operate satisfactorily, the following conditions should be checked before making any adjustment to the regulator :

(*a*) Be sure that the base of the regulator is properly earthed.

(*b*) Earth the regulator terminal marked " F " while engine is running at approximately the maximum generator output. If the generator charges satisfactorily with the " F " terminal earthed, the trouble is in the regulator, and it should be replaced or adjusted.

(*c*) If the generator does not charge with the " F " terminal earthed, remove the lead from the " GEN " terminal of the regulator and strike it against an earth such as the motor block. If no spark occurs, the trouble should be looked for in the generator. If a spark occurs, the regulator is probably at fault.

(*d*) A high charging rate may be caused by a shorted battery.

(*e*) A low charging rate may be caused by a loose connection in the charging circuit, sulphated battery plates, or other high resistances.

(*f*) With no connected electrical load except ignition and dash instruments, a low generator output with a fully charged battery indicates that the regulator is functioning properly.

The regulators are adjusted at the factory and, under ordinary circumstances, will not need any attention in service.

Do not set regulator voltage above maximum specified value.

PROCEDURE FOR CHECKING VIBRATING VOLTAGE REGULATOR

Cut-out Relay

With the voltmeter connected as illustrated in Fig. 8, gradually increase the engine speed and note the voltage at which the cut-out relay contact points close. With the ammeter connected as in Fig. 8, gradually decrease engine speed and note the reverse current necessary to open the points. If necessary, adjust according to instructions under Adjustments of Cut-out Relay.

Generator Output

To check the output of the generator, connect the ammeter and voltmeter to the regulator (Fig. 8). It is necessary to earth the "F" terminal temporarily while making this check to obtain the maximum output of the generator. A convenient method of earthing the "F" terminal is by touching a screwdriver to the "F" terminal and the base of the regulator. The generator voltage should be noted when checking the output, as a low voltage will prevent the generator from producing its rated output. To secure the correct voltage, include ¼-ohm variable resistance in the charging circuit and cut in the resistance until the correct voltage is obtained. If the generator does not build up to its specified value, the generator is probably at fault and should be removed and checked or the third brush adjusted.

Voltage-regulator Unit

To check the voltage at which the regulator is operating, disconnect the "IGN" lead from the regulator and place a jumper lead from the "IGN" to the "AMM" or "BAT" terminals and connect the ammeter and voltmeter leads to the regulator, as illustrated in Fig. 9. Gradually increase the engine speed until it is operating at a speed at which it would ordinarily produce maximum output. If less than 8 amps. is obtained, turn on the lights. Cut in the resistance until the output is reduced to 8–10 amps. After the regulator has reached its proper temperature (150° F., or very hot to the hand), retard the speed of the generator until the cut-out relay contact points open. Then increase to the original speed and with a generator output of 8–10 amperes check the voltage at which the voltage-regulator unit is operating (regulator cover must be in place). Refer to Adjustments for method of adjusting the voltage setting.

Note.—To maintain the 8–10 ampere output while making this check, it is recommended that a variable resistance of approximately ·25 ohm, with sufficient current-carrying capacity, be used in the charging

circuit. (in series at the "AMM" or "BATT" terminal of the regulator). Fig. 9 shows the method of inserting this resistance in the circuit when an AVR Electro-check is used.

Another method of checking the regulator voltage using a voltmeter and a fixed resistance is to disconnect the "BAT" ("AMM") lead from the regulator. Connect a fixed resistance unit, of $\frac{3}{4}$ ohm for 6-volt units and $1\frac{1}{2}$ ohm for 12-volt units, between "BAT" terminal of regulator and earth. Connect voltmeter from "BAT" terminal to earth. Where the unit under test is an "IGN" terminal-type regulator, disconnect "IGN" lead and place jumper from "IGN" to "BATT" terminals. Operate the dynamo at a speed at which it would ordinarily produce maximum output until the regulator reaches operating temperature. Then note the voltage at which the unit is operating.

Performance of Vibrating Voltage Regulator

(*a*) Excessive sparking and erratic operation of the voltage-regulator contact points may be due to low tension on the upper contact spring or misalignment of contacts. Such excessive sparking may, in time, oxidise the contact points sufficiently to cause high resistance and prevent the generator from charging.

Clean the contacts with a thin, fine-cut contact file to obviate this condition.

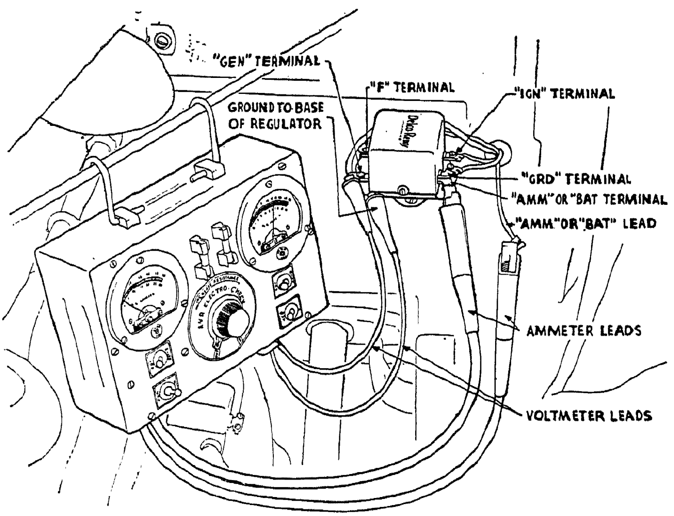


Fig. 8.—VOLTMETER CONNECTIONS FOR CHECKING CUT-OUT CLOSING VOLTAGE AND AMMETER CONNECTIONS FOR CHECKING REVERSE CURRENT OPENING OF CUT-OUT RELAY CONTACT POINTS

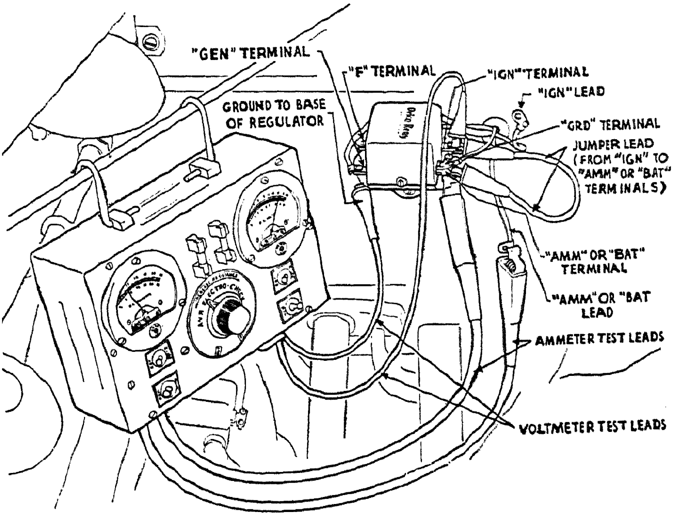


Fig. 9.—CHECKING VIBRATING REGULATOR OPERATING VOLTAGE
Voltmeter and ammeter connections with variable resistance in charging circuit for checking regulator operating voltage.

(*b*) The installation of radio by-pass condensers on the *field* terminal of the regulator or generator will cause the regulator contact points to oxidise. Oxidised points cause a high resistance, and may result in a low charging rate and a discharged battery. *Do not connect radio by-pass condensers to the field terminal of the regulator or generator.* If a condenser has been installed on the field terminal, clean regulator contacts with a small file.

(*c*) *Oxidised Contact Points.*—There are two convenient methods for detecting oxidised contact points on the voltage-regulator units without removing the regulator cover. First, if the unit is being checked on the car, disconnect the lead from the "IGN" terminal on the regulator and connect the ammeter test leads to the unit, as illustrated in Fig. 9. Run the engine at a slow speed until 4 or 5 amperes output is being obtained, then earth the "F" terminal of the regulator and note the difference in the ammeter reading. (Generator speed must be held constant.) If the ammeter reads 2 or more amperes higher with the "F" terminal earthed at the regulator, it indicates an excessive amount of oxide on the voltage-regulator contact points. The oxide on the points insets an additional resistance in the generator field circuit, resulting in a lower generator output.

(*Note.*—Disregard the initial surge of the ammeter needle and wait until it remains steady.)

Second, if the regulator is removed for a bench-test check, oxidised contact points may be detected by noting the speed at which the contact points on the cut-out relay close with and without the "F" terminal earthed.

(*Note.*—The generator commutator should be sanded before making this check.)

If the cut-out relay contact points close at a lower speed with the "F" terminal earthed, it indicates oxidised points on the voltage-regulator unit. For example, if the points close at 600 r.p.m. without the "F" terminal earthed, and by earthing this terminal they close at a speed of 500 r.p.m. or lower, it indicates an excessive amount of oxide on the regulator points. The points will normally close at a slightly lower speed with the "F" terminal earthed. If, however, they close at a difference in speed of 100 r.p.m. or more with this terminal earthed, the points should be cleaned. The presence of oxide on the contact points will make it necessary for the generator to be driven at a greater speed to build up sufficient voltage to close the cut-out relay points.

Cleaning Contact Points

Contact files should not be allowed to become greasy and should not be used on other metals.

Contact points can be cleaned without disturbing the regulator setting.

Do *not* use the file excessively on the small contact material; this is only a few thousandths of an inch thick.

Never use sandpaper or emery-cloth to clean contacts.

ADJUSTING VIBRATING VOLTAGE REGULATOR

Air Gap

With the fibre bumper barely touching the contact-spring post, check the air gap between armature and core centre. Adjust the air gap by bending the contact-spring post.

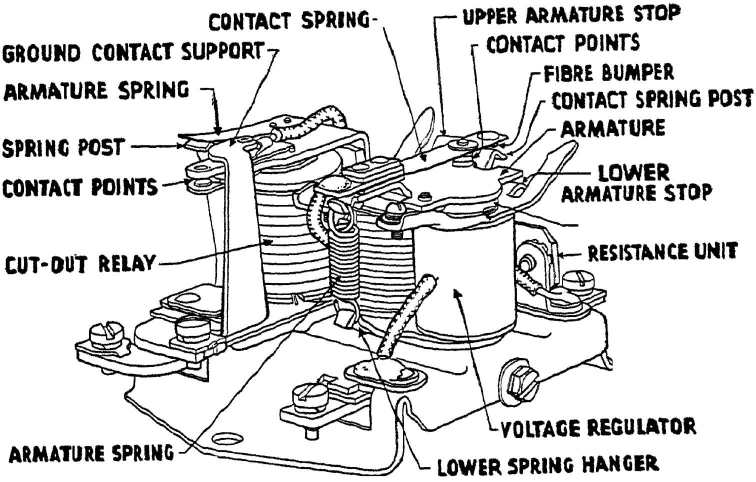
If it is impossible to secure the proper cold and hot regulator voltages, the air gap may be decreased to lower the cold setting with respect to the hot setting or increased to increase the cold setting with respect to the hot setting.

Point Opening

With the armature held down against the lower armature stop, measure the contact-point opening. Vary the point opening by adjusting the lower armature stop.

Gap between Fibre Bumper and Contact-spring Post

When the armature is up, check the gap between the fibre bumper and its stop. Adjust the upper armature stop to obtain the correct gap.



10.—VIBRATING VOLTAGE REGULATOR

Contact-point Spring Tension

Contacts should be adjusted to meet squarely and with a minimum pressure of 3½ oz. (Check pressure at the instant the points separate, using a spring scale of the type for checking distributor lever arm tension.) Adjust pressure by slightly bending the contact spring carrying the upper contact.

Regulator Voltage

Check the regulator operating voltage as previously described (refer to Fig. 9) with the regulator at the proper temperature. The voltage is regulated by slightly bending the spring hanger to which the lower end of the spiral spring is attached. Increasing the spring tension increases the voltage, and decreasing the tension decreases the voltage setting. If, when adjusting the regulator to the proper voltage, it is found that the spiral spring does not have enough tension to hold it in place, reduce the tension of the upper contact spring—but not less than the low limit specified. When checked on a bench test, the regulator should be in the same position as on the car (i.e. horizontal or vertical), and the base must be earthed.

Do not run generator or set voltage on open circuit. This will cause damage to the regulator.

OTHER TYPES OF CONTROL WITH THIRD BRUSH DYNAMOS

The type of control for an adjustable third brush dynamo using a thermostat controlled field resistance is described on page 8. This type

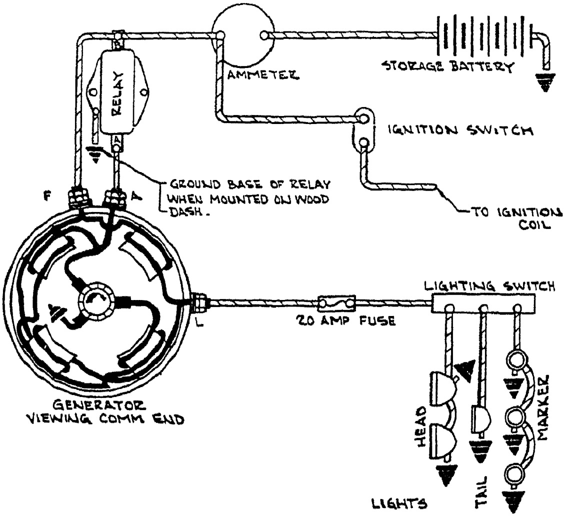


Fig. 11.—DIVIDED FIELD CIRCUIT LAMP LOAD DYNAMO

of unit, in addition to the third brush, employs a thermostat, mounted inside the dynamo, which opens its points as the dynamo becomes hot (165° or 200° F., depending on the type of thermostat used), and inserts resistance into the generator field circuit, reducing the generator output.

The use of manually controlled field resistance is referred to on page 10.

Adjustable Third Brush with Divided Field Circuit

On this type of application the dynamo has two sets of field coils. With no lights turned on, only one set is used. When the lights are turned on, the current to the lights flows through the auxiliary coils, increasing the dynamo field strength and thus the dynamo output. Some applications of this type use two cut-outs, as illustrated in Fig. 12. Two readings are necessary in checking the divided field generator, the output at the "A" terminal, and the lamp load at the "L" terminal. The output at the "A" terminal is adjusted to the correct value by the third brush adjustment. The lamp load connected to the "L" terminal

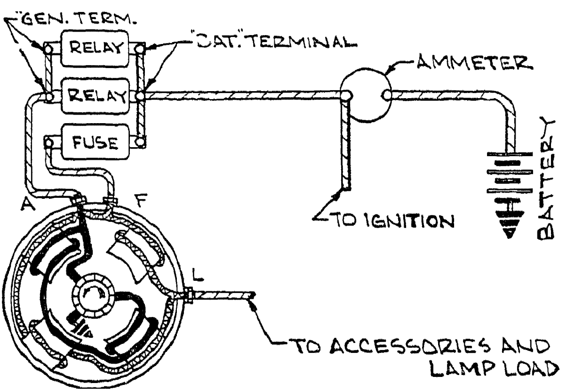


Fig. 12.—DIVIDED FIELD CIRCUIT DYNAMO WIRED WITH TWO CUT-OUTS

does not register on the dash ammeter and must never exceed the maximum specified.

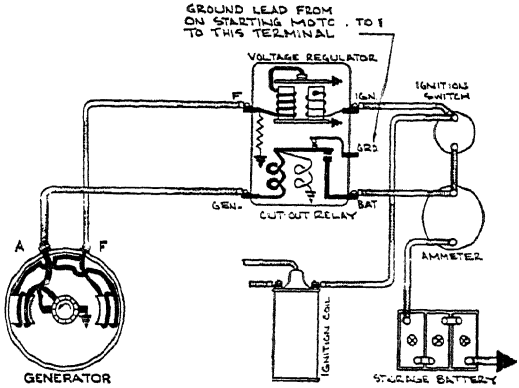


Fig. 13.—SPLIT FIELD TYPE OF DYNAMO

Split Field Type

This type of dynamo has a third brush field and a shunt field connected together at the field terminal (Fig. 13). The output curve developed by the combined windings represents a composite of the performance curves of the individual fields. Vibrating voltage regulation is used with this type of generator to regulate the output to the correct value as required by the connected electrical load and condition of charge of the battery.

TWO-BRUSH DYNAMOS

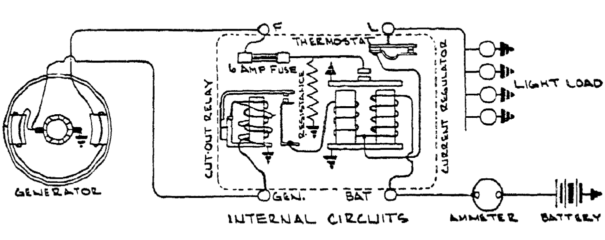
The above details deal with forms of output control or regulation applied to third-brush dynamos. We will now consider the methods used for controlling the field current of a shunt wound, two-brush dynamo, by means of (*a*) current regulator, and (*b*) current and voltage regulator.

The shunt wound dynamo does not have a third brush, the field circuit being connected across the two main brushes through the regulator unit. This type of dynamo reaches its maximum output at a lower speed and maintains a constant output throughout the higher speed ranges without the "taper-off" characteristic of third-brush dynamos. External current regulation is required with this type of dynamo.

VIBRATING CURRENT REGULATOR

The current regulator (*see* Fig. 15) consists of a current regulator unit and a cut-out relay mounted on the dynamo or the engine side of the dash.

Fig. 14.—WIRING DIAGRAM OF A CURRENT REGULATOR



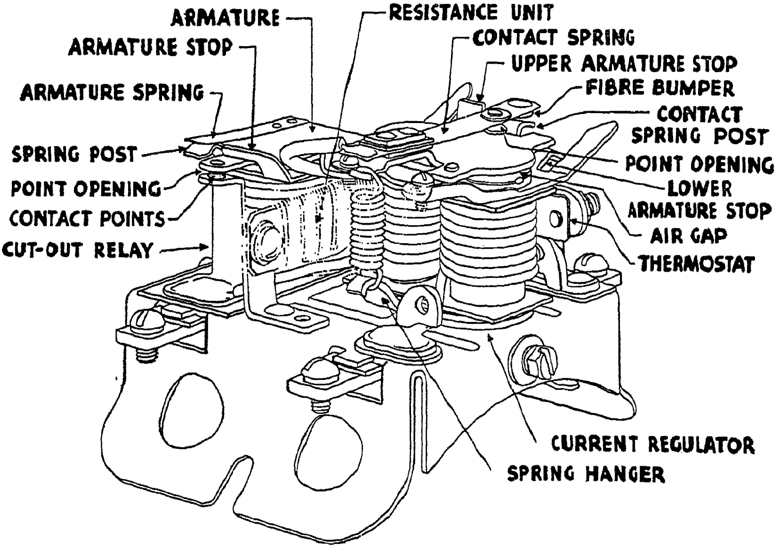


Fig. 15.—CURRENT REGULATOR

The current regulator limits the generator output to a specified value which is governed by the setting of the regulator. The contact points are normally held in a close position, due to the tension on the armature by the armature spring. When the magnetic pull on the armature overcomes the spring tension, the contact points open and insert a high resistance in the shunt field circuit of the generator. This resistance in the field circuit reduces the generator output so that the spring tension loses the contacts and the output again increases. The armature vibrates many times per second, resulting in a practically constant generator output at all speeds, provided the generator is being driven at a speed fast enough to enable it to reach its maximum output. The maximum output of the generator depends upon the setting of the current regulator.

When the lights are turned on, the generator output is automatically increased by 50 per cent. of the additional load. If the light load is increased beyond luminations or a short circuit occurs, the bi-metal thermostat points open and vibrate, causing the lights to flicker. When this occurs, the light load should be reduced or the short circuit condition eliminated. The thermostat points open with 20 amps. flowing and when the surrounding temperature is 210° F.

Some of the current regulators are compensated for temperature, which means that the current output of the generator will decrease below the normal setting as the operating temperature becomes abnormally high.

Fig. 16.—CURRENT REGULATOR

Showing voltmeter and ammeter connections for checking the cut-out closing voltage and the reverse current necessary to open the cut-out contact points. Use these connections for checking generator output.

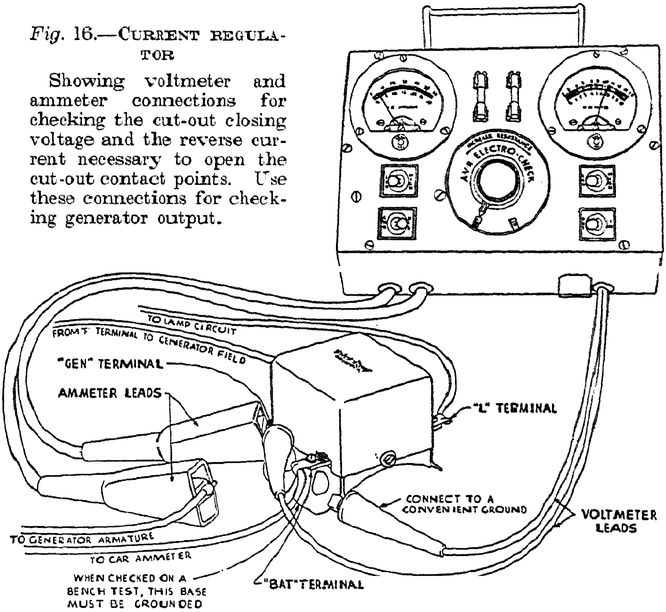
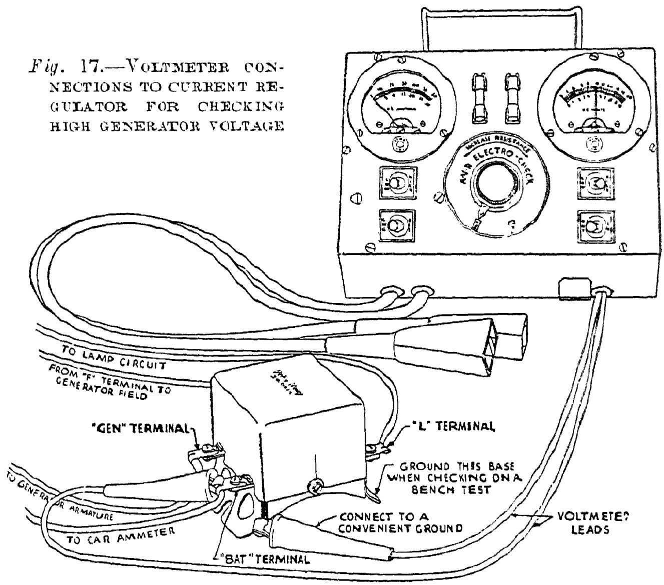


Fig. 17.—VOLTMETER CONNECTIONS TO CURRENT REGULATOR FOR CHECKING HIGH GENERATOR VOLTAGE



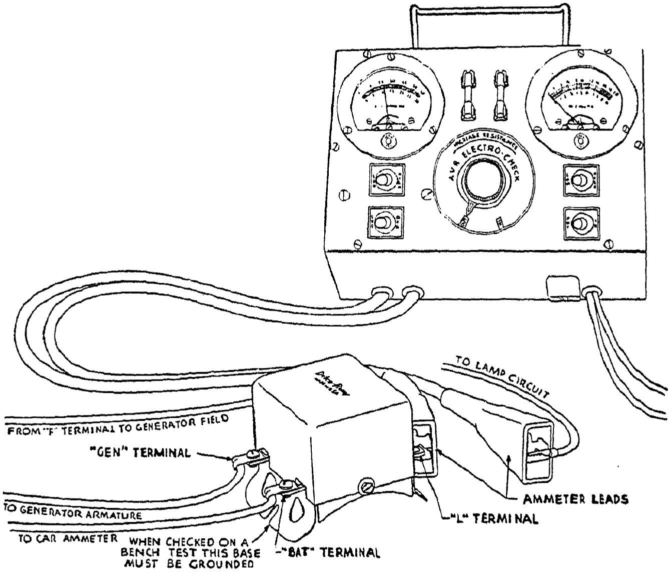


Fig. 18.—AMMETER CONNECTIONS TO CURRENT REGULATOR FOR CHECKING LAMP LOAD

Likewise, the output will increase when the temperature of operation becomes abnormally low.

Checking Current Regulator

(1) With the ammeter and voltmeter connected as in Fig. 16, check the voltage at which the cut-out relay contact points close and the reverse current at which they open. Gradually increase and decrease engine speed when making checks to obtain accurate meter readings.

(2) Use the same meter connections as in Fig. 16, to check the generator output. Check the output with the lights on and off. When the lights are on the output is automatically increased, and with the lights off it is decreased.

The generator voltage should be noted when checking the output. Connect a voltmeter to the regulator as shown in Fig. 17. If the dynamo voltage is too high or too low, remove and check on a test bench. Low generator voltage will prevent the output from reaching its maximum and high voltage may result in damage to the generator or regulator.

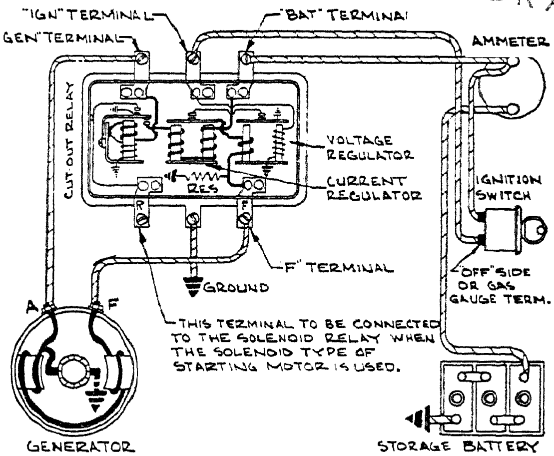
(3) It is important, with this type of regulator, never to exceed the total allowable lamp load. To check the lamp load, connect the ammeter as shown in Fig. 18 and turn the lights on. If the ammeter reading exceeds specifications, reduce the lamp load.

Adjustments

Contact points should be cleaned as described previously.

Air gap, point opening and fibre bumper gap adjustments are as described on page 192 for the vibrating voltage regulator.

Spring tension, measured at the contacts, should be approx. $2\frac{3}{4}$ ounces and may be adjusted by slightly bending the contact spring.



19.- : DIAGRAM OF A SHUNT DYNAMO WITH CURRENT ND VOLTAGE REGULATION

Adjust current output by slightly bending the spring hinges to which the lower end of the spiral spring is attached. Increasing the spring tension increases the current output. Decreasing the tension decreases the output. The current regulator unit operates only at the value for which it has been set.

THE CURRENT AND VOLTAGE REGULATOR

When these two units are used together in a Delco-Remy system, they are mounted, with a cut-out relay, on a single base and are enclosed by a single cover. Either the current regulator unit or the voltage regulator unit will operate at any one time, never both at the same time.

When the requirements of the connected electrical load are large and the battery is low, the current regulator unit operates to prevent the output from exceeding the rated output of the generator and the voltage regulator unit is inoperative. If the requirements of the connected electrical load are reduced and the battery comes up to charge, the voltage regulator unit operates to prevent high voltage at the battery and in the circuit, and the increasing resistance of the battery as it becomes charged tapers down the generator output. The output is thus reduced, by the action of the vibrating voltage regulator unit, to what is required by the connected electrical load plus a small sustaining charge of a few amperes to the battery.

Voltage Regulator

The construction of the voltage regulator unit is similar to the current regulator except that one of the cores is wound with a large number of

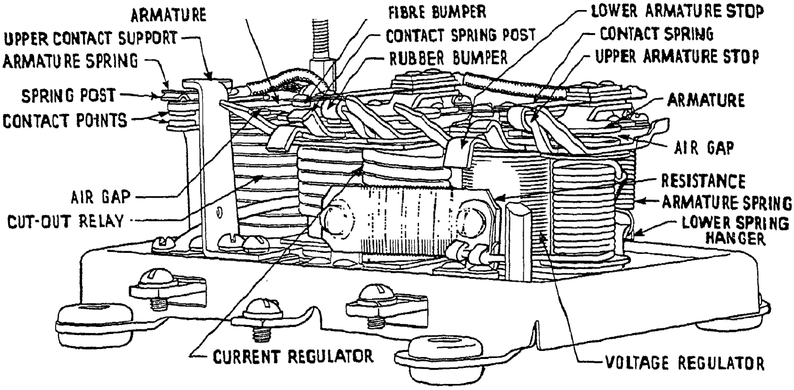


Fig. 20.—Voltage current regulator

turns of small wire connected between earth and petrol gauge terminal (*see* gas gauge terminal, Fig. 19) on the ignition coil or the "off" side of the ignition switch. The current in this winding varies with the battery voltage. Whenever the battery voltage reaches a pre-determined value, the magnetic pull on the armature overcomes the spring tension and the contact points open, inserting a resistance into the field circuit of the generator. As soon as the contacts open, the voltage immediately drops and the points close. This cycle occurs many times a second, resulting in a generator voltage that is held practically constant.

The voltage coil of the regulator is connected at the "off" side of the ignition switch or the petrol gauge terminal on the ignition coil, which is practically at battery voltage. Therefore, the regulator regulates for battery voltage, thus eliminating the effect, due to line drop between the generator and battery, with varying amounts of current flowing.

There are a few turns of heavy wire around the other core of the voltage regulator unit, in series with the generator field circuit and aiding the main winding of the regulator unit. When the voltage regulator contacts open, the current in this aiding coil is immediately reduced to zero, thus enabling the contacts to quickly close and, in this way, to increase the speed of vibration of the contact points.

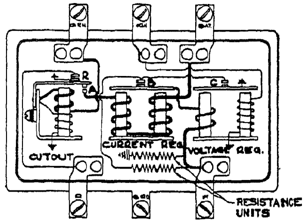


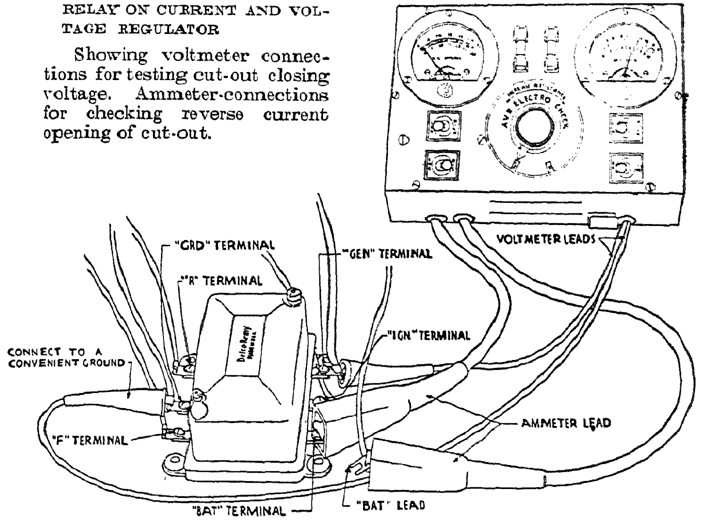
Fig. 21.—Two resistance units connected in field circuit

Resistance Units

Recent dynamos with increased outputs have made it desirable to use different resistance values across the current regulator and voltage regulator than

Fig. 22.—CHECKING CUT-OUT RELAY ON CURRENT AND VOLTAGE REGULATOR

Showing voltmeter connections for testing cut-out closing voltage. Ammeter-connections for checking reverse current opening of cut-out.



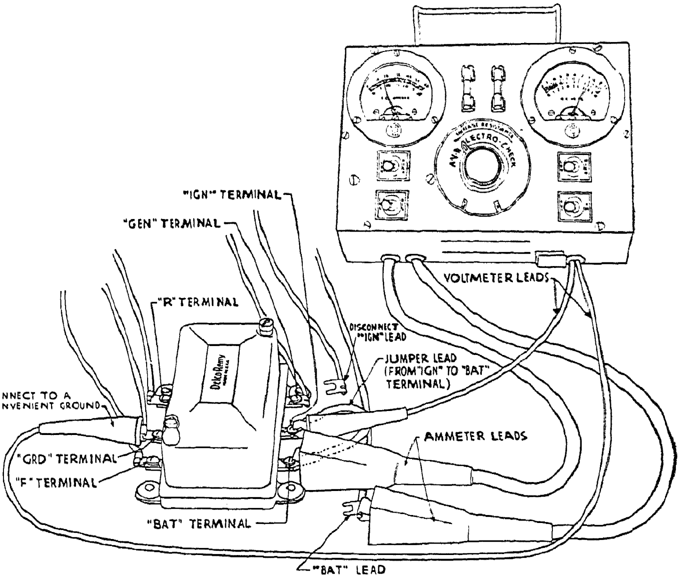


Fig. 23.—CHECKING VOLTAGE REGULATOR

Voltmeter and ammeter connections with variable resistance in charging circuit.

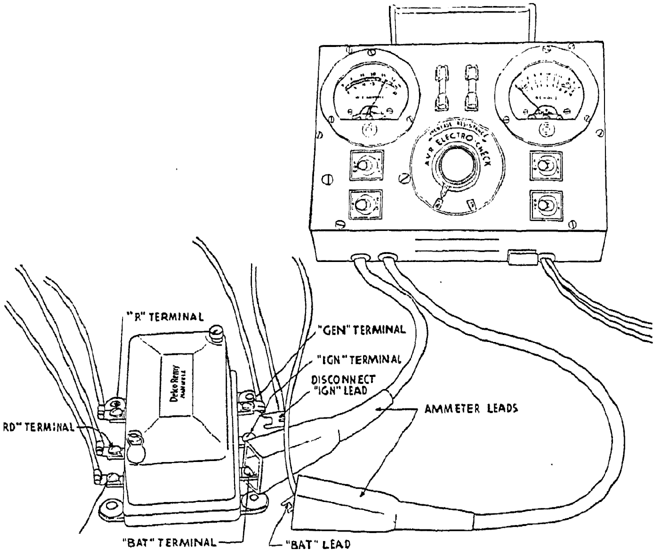


Fig. 24.—AMMETER CONNECTIONS FOR CHECKING CURRENT SETTING OF THE CURRENT REGULATOR

were formerly used. The later type regulators have two resistance units of different values connected in the generator field circuit, as shown in Fig. 21. This arrangement permits the use of a lower value resistance with the current regulator operating than is necessary with the voltage regulator. When the current regulator contacts open, the two resistance units in parallel will reduce the generator output to the current regulator setting. When the voltage regulator contacts open, only the high value resistance is inserted in the field circuit, which reduces the charging rate to a minimum with a fully charged battery and no connected load. This resistance is of sufficient value to prevent the generator voltage from " creeping " or increasing due to continued high speed operation with a fully charged battery. The above arrangement reduces sparking and oxidising of the current regulator contacts and permits satisfactory voltage regulation of higher output generators.

Rough Check to Determine Location of Trouble

If the generator and regulator do not operate satisfactorily, check in the same way as described on page 188 under the above heading. If the generator charging rate is too high or too low, check the settings of the current and voltage regulator units. With no connected electrical load except ignition and petrol gauge, a low charging rate with a fully charged battery indicates that the regulator is functioning properly.

Checking Cut-out

Voltmeter and ammeter connections for checking the cut-out operation are shown in Fig. 22. When checking on a bench test, the regulator must be earthed by connecting a lead from the " GRD " terminal to earth.

Testing Voltage Regulator Unit

The method of testing the voltage regulator unit is the same as described on page 189. Fig. 23 gives the ammeter and voltmeter connections. Check the voltage at a generator speed of 2,000–3,000 r.p.m. with 8–10 amps. flowing.

Testing Current Regulator Unit

Remove the jumper lead, and with the " IGN " lead disconnected from the regulator, connect the ammeter test leads to the regulator as shown in Fig. 24. Turn on the lights and gradually increase the speed of the generator until the output remains constant. Under this condition, the output of the generator will be the amount for which the current regulator is adjusted.

It is not absolutely necessary to turn on the lights when checking the current regulator, but, in case the battery is fully charged, it will prevent excessively high voltage within the electrical system while making this check.

Conditions Affecting Performance

Causes of excessive sparking at the contacts, and erratic operation and methods of testing for oxidised points are dealt with on pages 190 and 191.

Adjustments

The air gap, point openings, etc., are adjusted in the same manner as described on pages 192 and 193.

The current setting of the current regulator is adjusted by bending the lower spring hanger.

ADJUSTMENTS AND MAINTENANCE OF DYNAMOS

If a generator is not performing according to specifications, and it has been determined that the cut-out relay or regulator is not at fault, the generator should be removed and checked thoroughly on a bench test.

Adjusting Dynamo Output

The output of third-brush generators can be changed by shifting the position of the third brush with respect to the main brushes. The third brush is mounted on a movable plate, located inside the commutator end frame. This plate is usually held in place by a clamp and a small round-head screw, located on the outside of the commutator end frame on the

smaller-size generators. In order to adjust the charging rate to a greater value, loosen the locking screw and shift the third brush in the direction of armature rotation. The output is decreased by shifting the third brush opposite to the direction of armature rotation. After adjustments have been completed, tighten the lockscrew so there will be no change in output while the generator is in operation.

When checking or adjusting the generator output, it is essential to use an accurate reading ammeter connected in series in the charging circuit at the generator terminal, rather than to use the dash ammeter. In checking the output of any generator, it is recommended that an accurate reading voltmeter be connected from the generator-armature terminal to earth at the same time the current output is checked.

Never set the output of a generator beyond the maximum safe specified value.

Some generators are air-cooled by means of a powerful centrifugal fan, incorporated in the generator drive pulley. Air-cooling the generator allows it to carry a heavier load without danger of overheating. A generator ventilated in this manner will carry a greater load than a non-ventilated unit and still run 80° F. to 100° F. cooler.

Adjusting Brush Tension

In case the brush-spring tension becomes weak, the charging rate will be reduced and more or less arcing and burning of the commutator will result because of poor contact of the brushes. Excessive spring tension will cause the commutator and brushes to wear faster, reducing the amount of service to be obtained from them. The brush-spring tension should be within limits for the particular model being checked. Brushes should be removed and checked to determine if they are seating properly. The " pigtail " lead connection at the brush should be checked to see that it is tight. A loose connection at this point causes a high resistance, forcing the generator to build up its voltage to a dangerously high value.

Bedding Brushes

Brushes used in the swivel-type holders should be well bedded on the commutator in order to obtain the correct generator output. To bed the brushes in these types of holders, wrap a strip of No. 00 sandpaper around the commutator, with the rough side next to the brush or brushes. A few strokes with the sandpaper will form the brush seat correctly. *Never use emery cloth to seat brushes.*

With reaction-type brush holders, where the brush " floats " in the holder, the brushes attain the proper seat during the normal operation of the generator. *Do not seat brushes in reaction-type holders.* If the brushes in the reaction-type holder do not seat properly, check the holders for burrs or other defects which may cause the brush to stick. A rough or burred commutator may cause brushes to seat improperly, and it should be smoothed up by using sandpaper.

Testing for Internal Defects in Dynamo

A set of test points provides a very simple but practical method of checking for earths, short- or open-circuits within the dynamo or generator. The set consists essentially of an ordinary lamp provided with two insulated leads attached to the test points proper, and connected to the mains. When the test points are brought together, current will pass and the lamp will light. If a wire or lead is thought to be broken, it may easily be checked by placing one test point on one end, and the other test point at the other end of the wire. If the lamp lights, the lead is not broken. On the other hand, if the lamp does not light, it indicates an open-circuit condition exists.

The following conditions can be checked with the test points :

Open-Circuit in Field Coils

To test for open circuits in the field coils, use the test points by placing one point on each terminal of the coil being checked. If the lamp fails to burn it shows that the coil is open-circuited and it should be replaced. Insulate the field-coil terminals before checking for an open-circuit. If the generator has a thermostat, it is necessary that the resistance unit be checked for open-circuit. An open-circuit in the field circuit will prevent the generator from charging.

Earthed Field Coils

The field-earth connections should be removed before making this check. To test for earths, place one test point on the frame of the generator and the other one on a terminal of the field coil. If the lamp lights, it indicates an earth.

Insulated Main Brush Earthed

Insulate the generator brushes from the commutator by placing a strip of heavy paper under the brushes. Use the test points between the insulated main brush arm to a convenient earth. If test lamp burns, the brush arm mounting stud is earthed.

Earthed Armature

To check for an earthed armature winding, raise all the generator brushes and insulate them with pieces of cardboard from the commutator. (Be sure that the commutator is clean and that there are no particles of carbon or copper between the bars.) Place one of the test points on the armature shaft and the other on the commutator. If the lamp burns, it . indicate earthed commutator or armature coil.

Open-circuited Armatures

To accurately check for an open-circuit condition, it is necessary to use the test points and an accurate-reading voltmeter. To make this check, remove the armature from the car.

Connect the terminals of a storage battery to points on the commutator which are diametrically opposite. In case a bar-to-bar test fixture is used, a rheostat or resistance of some kind is usually included in the circuit and the test points are fixed so that it is only necessary to rotate the armature by hand (*see* Fig. 25). When testing for open-circuited armatures, the rheostat or resistance should be cut out entirely. With a pair of test points connected to the 15-volt scale of the voltmeter, measure the voltage across each two adjacent commutator bars (*see* Fig. 25). If there is an open-circuited coil, the voltage reading will increase to approximately full battery voltage. The test points should be shifted one bar at a time until every commutator bar has been checked.

Short-circuited Armatures

If there are no open-circuited coils, the armature should next be tested for short-circuited coils. *Always make an open-circuit test before proceeding with short-circuit test, in order to avoid the possibility of damaging the millivoltmeter.*

The armature is connected as described in the paragraph under " Open-circuited Armatures " (Fig. 25), except that for this test, the one-tenth ($\frac{1}{10}$) or milli-volt scale is used instead of the 15-volt scale. The voltage drop between each two adjacent commutator bars is measured by slowly turning the commutator by hand. The readings on the voltmeter should be approximately the same. If any of them drop nearly to zero, it will indicate that one or more of the armature coils are short-circuited.

Caution.—In taking these readings, care should be taken to keep the points on adjacent bars, otherwise the voltage drop may be sufficient to injure the voltmeter.

Another method of testing for a short-circuited armature is known as the " Growler " test (*see* Fig. 26). This test is very satisfactory and more easily accomplished than the one just described. The armature to be tested is placed on the " Growler," which is a transformer. A thin strip of steel is placed on top of the armature core and an alternating current passed through the transformer.

The armature is rotated slowly by hand, keeping the steel strip uppermost on the core (*see* Fig. 26). A short-circuit in the windings will cause the strip to become magnetised, and to vibrate very perceptibly. Open-circuited armatures cannot be detected in this manner.

A short-circuit may be either in the windings or at the commutator. Short-circuits at the commutator are usually caused by foreign matter in the slots between adjacent bars, defective mica insulation, or burred commutator riser bars. Unless the fault is visible to the eye it is not advisable to attempt repairs. Only genuine Delco-Remy armatures should be used for replacement.

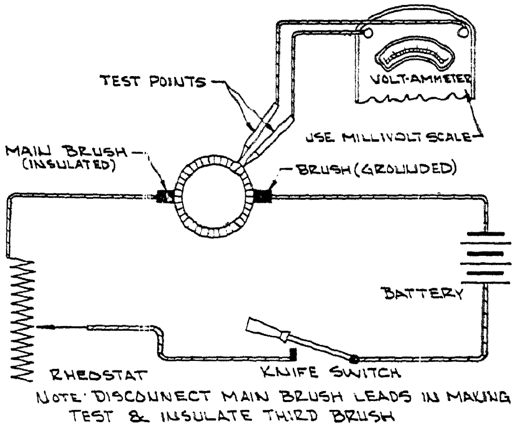


Fig. 25.—TEST CONNECTIONS FOR OPEN AND CIRCUITED ARMATURES

Inspection and Maintenance

It is advisable to inspect the generator at least every 20,000 miles, and to make any adjustments or repairs needed. Have the various parts taken out, thoroughly cleaned and greased, and any other parts excessively worn, repaired or replaced. If the commutator is worn or eccentric (out of round) it should be turned in a lathe to true it. The mica in the commutator should be undercut. Commutator and brushes should be kept clean. Brushes should seat well. All connections in the charging circuit should be kept tight and clean. (A loose or corroded connection causes high resistance and may cause the generator voltage to build up to a dangerously high value.)

Bearings

Annular ball bearings and bronze bearings are used in practically all generators. Some generators use the annular ball bearings on both ends of the shaft, while others use a bronze bearing on one end and a ball bearing on the other end. When the generator is being overhauled, the bearings should be cleaned and well oiled before being assembled.

Lubrication

All bearings provided with hinge-cap oilers should be supplied with 8–10 drops of light engine oil every 1,000 miles. Generators having ball bearings that are provided with grease-cups should have the grease-cups filled with special ball-bearing grease every 5,000 miles.

Do not Operate Dynamo on Open-circuit

An important factor that must not be overlooked is that the generator must not be operated unless it is connected to a battery, or damage to the unit will result, as the battery plays an important part in maintaining a normal voltage condition. When the generator is operated on open-circuit, the voltage will rise abnormally high, thus increasing several times the normal amount of current through the field coils, and cause the insulation on the field coils and armature to be burned.

If the generator is to be operated without being connected to a battery, it should be short-circuited by disconnecting the lead that is connected to the generator side of the cut-out relay and connecting it to a convenient earth.

CUT-OUTS

A cut-out relay is used to complete the circuit between the generator and battery. When the generator voltage exceeds the battery voltage, the contact points in the relay close and the circuit between the generator and battery is completed. When the battery voltage exceeds the generator voltage, the contact points open to prevent the battery from discharging through the generator windings. This unit is usually mounted on the generator frame, although, if a regulator is used, it is usually mounted on the same base as the regulator unit. The operation and adjustment of the relay is the same whether it is mounted as an individual unit or with a regulator.

The relay consists essentially of a set of contact points and a coil winding. The relay coil consists of a heavy series (current) winding and a shunt (voltage) winding. The shunt winding is connected to the "GEN" terminal of the relay and is earthed to the base of the relay. The actual closing of the contact points is caused by the magnetism created by the shunt winding when the generator operates at a sufficient speed to charge the battery. The series winding is connected in series with the contact points in the charging circuit, and current flows only in this winding when the contact points are in a closed position. When the battery voltage exceeds the generator voltage, the current flows in a reverse direction (from battery to generator) in the series winding to oppose the pull of the shunt winding and cause the contact points to open.

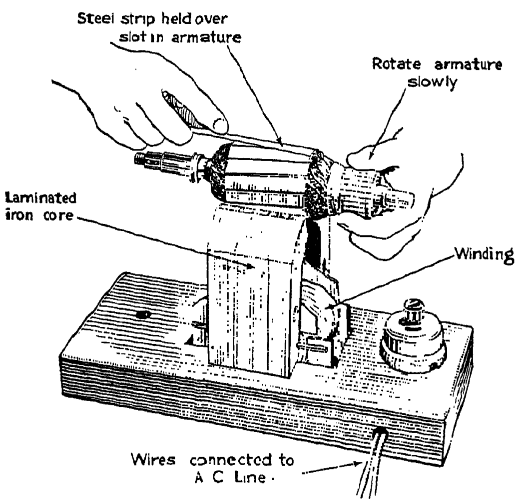


Fig. 26.—GROWLER TEST FOR SHORT-CIRCUITED ARMATURE

Adjustment of Cut-outs

Cut-out relays are designed to close at a predetermined voltage and to open with a small reverse current flowing.

Specifications for the cut-out relays are shown in the tables.

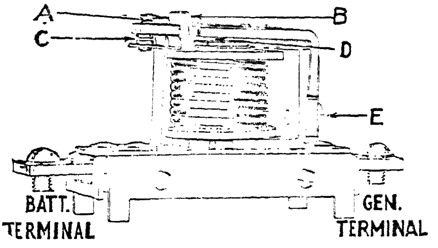


Fig. 27. DELCO-REMY CUT-OUT

A, spring post. B, armature stop. C, contact points. D, air gap. E, air gap adjusting screw.

Air Gap

With the contact points closed, measure the air gap between the armature and core centre at point *D* (Fig. 27). Adjust the air gap by loosening the two screws *E*, and move the armature up or down as required. If necessary, align the support carrying the lower contact so that the air gap between core and armature will be uniform.

Point Opening

Measure the contact-point opening with the armature in the up position. Adjust by bending armature stop *B*. On the relays equipped with an upper set of points, adjust the point opening by bending the support carrying the upper contact point. Clean contact points with a thin, fine-cut contact file if pitted or burned.

Cut-out Closing Voltage

Connect an accurate-reading voltmeter to the relay terminal marked "GEN" and to a convenient earth. Start the engine and gradually increase the speed until the contact points close. This is the *closing voltage* of the relay, and it can be adjusted by adjusting the spring post *A* (refer to Fig. 27). Bending *A* to increase the armature-spring tension will increase the closing voltage, and decreasing the spring tension will decrease the closing voltage.

The generator commutator should be sanded before making voltage check. Oil or "gum" on the commutator will not affect the closing voltage of the relay points, but makes it necessary for the generator to be driven at a faster rate of speed in order to produce sufficient voltage to close the relay-contact points. Check the spring tension and seats of generator brushes.

Correcting Reversed Polarity

If the generator or battery is removed for any reason it is possible that the polarity of the generator may be reversed. Reversed generator polarity will cause the cut-out relay points to vibrate and burn. This condition can be corrected by momentarily connecting a short jumper lead from the "Batt" to the "Gen" terminals of the relay, after all lead connections have been made to the relay and before the engine is started. This should always be done when a generator has been removed and replaced.

Testing Procedure

If the ammeter fails to show " Charge " with the engine running and the generator turning over at charging speed, a very simple test can be made to show if the trouble is in the cut-out relay. Take a short length of wire and connect it to the battery and to the generator terminals of the cut-out. If the ammeter then shows " Charge " the trouble is in the cut-out, and it should be replaced. Another simple test to determine if the generator is charging is to take a short piece of wire and touch it against the generator terminal of the cut-out and an earth. If the generator is charging there will be a flash when the wire is touched to earth.

TABLE I

CURRENT AND VOLTAGE REGULATOR TEST SPECIFICATIONS

Voltage Regulator Air Gap	·063 in.
Current Regulator Air Gap	·075 in.
V. & C. Regulator Point Opening	·020 in.
V. & C. Regulator Contact Spring Tension	3·5 oz.
V. & C. Regulator Fibre Bumper Clearance	·010 in.
Relay Air Gap	·020 in.
Relay Point Opening	·020 in.

Relay Points Open with 0–4·0 amps. reverse current.

Spec. No.	*CURRENT REGULATOR* *Current Setting* *(Amps.)*	*VOLTAGE REGULATOR* *Voltage Setting* *(Closed Circuit)**		*CUT-OUT RELAY* *Points Close* *(Volts) 70° F.*
		70° *F.*	150° *F*	
1293	26–28	7.0–7·4	6·95–7·15	6·9–7·6
1300	20–23	7·5–7·95	7·4–7·6	6·9–7·6
1401	20–22	7·0–7·4	6·95–7·15	6·9–7·6
1404	16–18	14·2–15·0	14·1–14·5	12·8–14·4
1411	20–22	7·0–7·4	6·95–7·15	6·9–7·6
1416	24–26	7·0–7·4	6·95–7·15	6·9–7·6
1418	28–30	7·5–7·9	7·4–7·6	6·9–7·6
1419	24–26	7·5–7·95	7·4–7·6	6·7–7·6
1420	16–18	14·2–15·0	14·1–14·5	12·3–13·7
1421	13	7·5–7·95	7·4–7·6	6·4–7·1
1422	26–28	7·0–7·4	6·95–7·15	6·3–6·9
1427	11·5–13·5	14·2–15·0	14·1–14·5	12·8–14·2
1429	19–21	14·2–15·0	14·1–14·5	12·8–14·2
1430	7–9	14·2–15·0	14·1–14·5	12·3–13·7
1431	9–11	14·2–15·0	14·1–14·5	12·3–13·7
1432	26–28	7·5–7·9	7·4–7·6	6·9–7·6
1435	24–26	14·2–15·0	14·1–14·5	12·3–13·7
1436	12–14	14·2–15·0	14·1–14·5	12·3–13·7
1437	24–28	14·2–15·0	14·1–14·5	12·3–13·7
1441	34–36	7·0–7·4	6·95–7·15	6·9–7·6
1442	34–36	7·0–7·4	6·95–7·15	6·3–6·9
1443	29–31	7·0–7·4	6·95–7·15	6·9–7·6
1444	14–16	14·2–15·0	14·1–14·5	12·3–13·7

* Operate generator at speed 25% above speed at which it first reaches rated output and adjust current to 8–10 amps.

TABLE II

VOLTAGE REGULATOR TEST SPECIFICATIONS

Regulator Air Gap	·063 in.
Regulator Point Opening	·020 in.
Regulator Contact Spring Tension	3·5 oz.
Regulator Fibre Bumper Clearance	·010 in.
Relay Air Gap	·020 in.
Relay Point Opening	·020 in.

Relay Points Open with 0–4·0 amps. reverse current.

Spec. No.	*REGULATOR Voltage Setting (Closed Circuit)**		*RELAY Points Close (Volts) 70° F.*
	70° F.	*150° F.*	
1294	7·5–7·9	7·4–7·6	6·9–7·6
1406	7·25–7·65	7·2–7·4	6·9–7·6
1409	14·2–15·0	14·1–14·5	12·8–14·2
1423	6·95–7·45	6·95–7·15	6·9–7·6
1438	14·2–15·0	14·1–14·5	12·4–13·6
1439	7·25–7·65	7·2–7·4	6·2–6·9
1445	7·5–7·9	7·4–7·6	6·3–6·9
1449	7·3–7·6	7·25–7·35	6·2–6·8

*Operate generator at rated speed for maximum output and adjust current to 8–10 amps.

SPECIAL NOTES ON REGULATOR PERFORMANCE AND CHECKS

(1) A regulator cannot increase the generator output beyond the generator's designed maximum, since the function of the voltage regulator unit is to reduce the output when the electrical circuit requirements are reduced and the battery is approaching a charged condition. The current regulator unit is a current limiting device, preventing the generator from exceeding its designed maximum.

(2) The voltage regulator unit limits the voltage of the circuit, thus protecting the battery and the distributor points, lights, and other accessories from high voltage.

(3) The current regulator unit is a protection to the generator, preventing it from exceeding its maximum rated output.

(4) Never set the current regulator above the maximum specified output of the generator.

(5) Many of the regulators are designed to be used with a positive earthed battery only, while others are designed to be used with a negative earthed battery only. Never attempt to use the wrong polarity regulator on an application.

TABLE III

STEP-VOLTAGE CONTROL TEST SPECIFICATIONS

	VOLTAGE CONTROL UNIT								CUT-OUT RELAY			
Spec. No.	Air Gap (Inches)	Point Opening (Inches)	Contact Spring Tension (Oz.)	Armature Travel (Inches)	Points Open (Volts)		Points Close (Volts)		Air Gap (Inches)	Point Opening (Inches)	Points Close (Volts) 70° F.	Points Open (Amps. Reverse Current)
					70° F.	180° F.	70° F.	180° F.				
1227	·057	·015	—	—	8·5–8·9	8·5–8·7	7·0–7·5	7·0–7·2	·015	·020	6·75–7·5	0–2·5
1242	·035	·010	·7–·9	·035	8·3–8·7	7·75–8·2	7·25–7·75	6·55–7·1	·015	·020	6·3–6·9	0–3·0
1289	·035	·010	·5–1·1	·030	15·4–16·35	14·4–15·35	13·9–15·1	12·8–14·1	·015	·020	13·0–14·2	0–4·0
1296	·035	·010	·7–·9	·035	8·3–8·7	7·75–8·2†	7·25–7·75	6·55–7·1†	·020	·020	6·3–6·9	0–3·0
1297	·035	·010	·7–·9	·035	8·3–8·7	7·75–8·2†	7·25–7·75	6·55–7·1†	·015	·020	6·3–6·9	0–3·0
1405	·035	·010	·7–·9	·035	8·3–8·7	7·75–8·2	7·25–7·75	6·55–7·1	·020	·020	6·4–7·0	0–3·5
1408	·045	·015	·7–1·4	·045	7·65–8·05	7·55–7·95	6·65–7·15	6·35–6·95	·015	·020	6·3–6·9	0–4·0
1410	·035	·010	·5–1·1	·035	8·1–8·55	7·65–8·05†	7·15–7·55	6·35–6·95†	·020	·020	6·3–6·9	0–3·5
1424	·045	·015	·5–1·1	·045	7·65–8·05	7·55–7·95†	6·65–7·15	6·35–6·95	·020	·020	6·3–6·9	0–4·0
1433	·035	·010	·5–1·1	·035	7·45–7·85	6·95–7·35	6·0 max.	6·0 max.	·020	·020	6·3–6·9	0–4·0
1440	·045	·015	·7–1·4	·045	14·1–14·7	14·1–14·7	12·0 max.	12·0 max.	·015	·020	12·9–13·9	0–4·0
1446	·015	·022	·7–·9	·060	28·5–31·5	26·5–28·5	15·0 max.	15·0 max.	·020	·030	24·5–27·5	3·0 max.

† Voltage at 150° F.

TABLE IV

CURRENT REGULATOR TEST SPECIFICATIONS

CURRENT REGULATOR UNIT

Spec. No.	*Current Setting* ...*es)* 70° *F.*	*F.*
1281 .		
1286 .		†7·5–8·
1287 .		

* Generator delivers 19–22 amps. with 11-amp. lamp load. † Generator delivers 11–13 amps. with 7-amp. lamp load.

§ Generator delivers 14–16 amps. with 11-amp. lamp load. ‡ Generator delivers 10–12 amps. with 7-amp. lamp load.

Current regulator: air gap ·057 in., point opening ·020 in., gap between fibre bumper and contact spring stop ·008 in., contact spring tension 2·25 oz. Cut out relay: air gap ·015 in., point opening ·020 in., points close 6·75–7·25 volts, points open 0–3·0 amps. reverse current.

TABLE V

CURRENT LIMIT RELAY TEST SPECIFICATIONS

Air gap ·020 in., contact point opening ·020 in., minimum spring tension of brass button 5 oz.

Spec. No.	*Starts Vibrating (Amps.)*	*Vibrates with Dead Short (Amps.)*	*Lockout Holds Open (Amps.)*
620 . .	25–30	2–15	—
620-A . .	25–30	*2–15	—
620-B . .	30–25	5–22	
620-C . .	20–23	2–15	
620-D . .	35–40	5–22	—
620-E . .	22–26	2–15	—
620-F . .	35–40	5–22	25–30
620-G . .	35–40	5–22	28–33

* Both units.

SPECIAL NOTES ON REGULATOR PERFORMANCE AND CHECKS—continued

(6) The majority of reported regulator troubles arise from dirty and oxidised contact points, which cause a reduced generator output. Clean the contact points with a thin fine-cut contact file. If the points are pitted, clean the pit with a spoon or ball-shaped file. NEVER USE EMERY CLOTH TO CLEAN CONTACT POINTS.

(7) On the no-" IGN " terminal type of voltage regulator, such as used on many of 1939 cars, the relay voltage must be set below the regulator voltage or the relay will not close until high generator speed is reached, thus causing run-down batteries. Too low a setting will cause the relay points to vibrate and burn. Make sure the relay is set within the limits given in the specifications. This type of relay may be set either hot or cold.

(8) The type of regulator which has an " IGN " terminal should have the cut-out relay voltage setting made with the relay cold (70° F.).

(9) Never attempt to set the voltage regulator unit on open circuit on the regulators, specifications for which are listed in Tables I and II. To do so will result in burned contact points, voltage regulator windings, and resistance units. With any of these conditions, check for an open circuit or excessive resistance in the car electrical charging circuit before reinstalling regulator. This type of regulator will operate with broken or open battery connections, without damage to the unit, as long as there is a connected light load of 5 amperes or more.

(10) On the type of regulator which has a rubber gasket, always replace the gasket upon reassembly, since this is a protection on the contact points, preventing dust and oil vapours from oxidising the contact points.

INDEX TO TEST SPECIFICATIONS

Model No.	*Spec. No.*	*Model No.*	*Spec. No.*	*Model No.*	*Spec. No.*	*Model No.*	*Spec. No.*
5539	1227	5595	1405	5827	1294	5860	1445
5540	1242	5596	1411	5828	1422	5861	1418
5541	1281	5597	1293	5829	1430	5862	1449
5542	1242	5598	1294	5830	1296	5863	1408
5543	1286	5599	1293	5831	1432	5864	1433
5544	1242	5600	1406	5832	1432	5865	1443
5545	1287	5800	1408	5833	1433	5866	1438
5546	1242	5801	1404	5834	1289	5867	1418
5548	1242	5802	1409	5835	1294	5868	1433
5549	1242	5803	1406	5836	1435	5869	1433
5550	1242	5804	1410	5837	1435	5870	1449
5551	1242	5805	1242	5838	1289	SM1719	1289
5554	1242	5806	1420	5839	1296	SM1739	1242
5555	1242	5807	1294	5840	1436	SM1780	1404
5556	1242	5808	1294	5841	1437	SM1891	1421
5557	1294	5809	1416	5842	1437	SM1957	1431
5558	1242	5810	1416	5843	1438	410-A	620-B
5559	1300	5811	1418	5844	1439	410-B	620-A
5560	1289	5812	1294	5845	1440	410-C	620
5581	1242	5813	1419	5846	1427	410-D	620
5582	1242	5814	1294	5847	1441	410-E	620-A
5583	1296	5815	1423	5848	1441	410-F	620-B
5584	1296	5816	1242	5849	1440	410-G	620-B
5585	1297	5817	1294	5850	1242	410-H	620-A
5586	1289	5818	1419	5851	1433	410-J	620-B
5587	1401	5819	1422	5852	1442	410-K	620-D
5588	1294	5820	1406	5853	1442	410-L	620-B
5589	1405	5821	1424	5854	1443	410-M	620-C
5590	1296	5822	1406	5855	1421	410-N	620-D
5591	1294	5823	1420	5856	1444	410-P	620-E
5592	1294	5824	1289	5857	1440	410-S	620-D
5593	1296	5825	1427	5858	1445	480-Z	620-F
5594	1405	5826	1429	5859	1446		

ENGINE TUNE-UP SERVICE AND EQUIPMENT

By S. G. MUNDY, M.I.E.E., A.M.I.A.E., M.I.M.T.

DURING recent years there has been a considerable development in specialised equipment for testing engines and electrical equipment. Apart from the necessity for acquiring sufficient knowledge to operate this equipment, it is equally necessary properly to appreciate its purpose, because, with the availability of modern testing equipment, there has been evolved a more concise understanding of the real problem involved in servicing the modern car.

When a car owner visits a garage or service station he does so because the *performance* of the car is not satisfactory. He desires the performance to be restored.

Engine Tune-up—What it Is

The restoration of car performance has been described as engine tune-up. Tune-up does not mean tinkering—adjusting this and that until the engine "seems" to run better. Neither does it mean that the service mechanic has to be a motor engineer capable of working out a combination of valve clearances, point setting, and sparking-plug gaps to suit his own ideas.

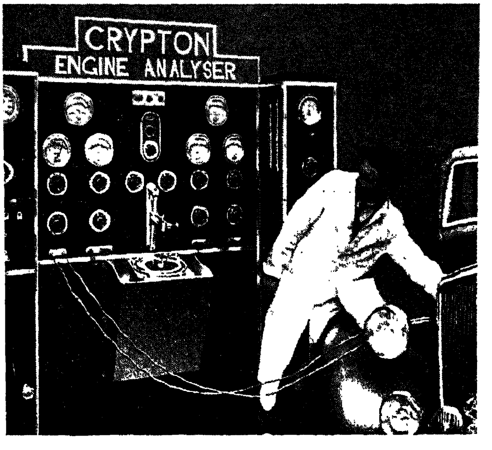


Fig. 1.—COMPLETE ENGINE TUNE-UP EQUIPMENT IN USE
(*Crypton Equipment Ltd.*)

Tune-up means restoring the original standards of adjustment. These standard adjustments were originally made at the car factory. They were *built into* the car by the manufacturer. They gave the car its original power, its speed, its acceleration, its economy. With normal wear the original adjustments have changed. Moving parts have worn,

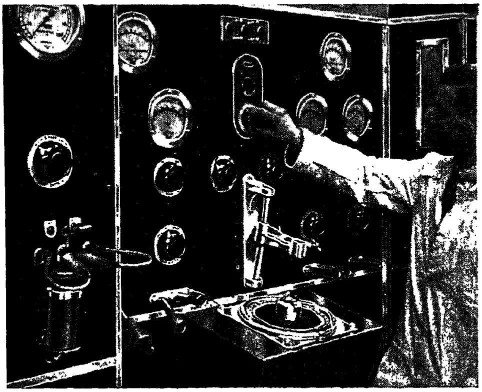


Fig. 2.—TESTING IGNITION COIL UNDER VARIABLE SPEED CONDITIONS

(*Crypton Equipment Ltd.*)

terminals have become corroded, springs have weakened, and passages have become clogged. The more miles the car has been operated the greater the degree of change and the consequent falling off in performance. Engine tune-up is a method which permits the service mechanic firstly to find out by systematic tests the alterations which have taken place in the original standards of adjustment, and to restore these standards by making such adjustments, fitting such replacements, or carrying out such repairs as the tests made prove to be necessary. Every service mechanic will appreciate that this method is much more satisfactory than the methods now so frequently used, which are in so many cases carried out in a haphazard way, and which in any case only correct the more obvious troubles instead of systematically analysing *all* the causes of lost car performance, and the work required completely to bring back *new-car performance*.

When a Tune-up is Required

The starting-point for the first tune-up after the purchase of a new car may be taken at a mileage of 4,000, this being 3,000 miles after the driving period at which the standard warranty of the car manufacturer expires.

It is expected that during the first 1,000 miles the ordinary minor adjustments necessary to a new car will have been made ; thereafter a tune-up should be applied every 3,000 miles.

At this mileage point—4,000 after purchase or 3,000 after the previous tune-up—the car owner can be assured that new-car performance can be maintained. Although the distributor, carburettor, and other vital units of the car will not have enough wear to require actual repairs or overhaul, the fine adjustments made at the factory will have altered with use and should be restored to their original standards.

At mileages of approximately 10,000 it will become necessary to carry out more complete reconditioning of individual units such as dynamo, starter, distributor, fuel pump, and carburettor.

The Advantages of a Tune-up

Complaints made by car owners of petrol consumption, missing, sluggish engine, poor acceleration, hard starting are all indications that a tune-up is necessary.

In recommending a tune-up for such complaints, the service mechanic should remember that the owner is entitled to know what it is proposed to do to his car and why. The average car owner will probably have some theory of his own as to why he is getting hard starting or poor mileage, and he expects the mechanic to offer some separate or distinct remedy, such as "cleaning sparking plugs," or "fit new contact-breaker points."

Fig. 3.—TUNING THE ENGINE WITH THE VACUUM GAUGE
(*Crypton Equipment Ltd.*)

It should be explained, however, that the cause of poor performance is the gradual alteration of all the standards of adjustment built into the engine, and that what you wish to do is to restore all these adjustments to their original settings, which may or may not involve new parts or reconditioning.

No service mechanic can give a car owner any real service by accepting instructions to "adjust carburettor," "clean plugs," "clean contact-breaker points," or similar individual jobs. Regardless of what the owner thinks he needs done, what he really needs and expects is "to have his car fixed"—or have its performance restored.

The only satisfactory method of doing this is firstly by systematic examination to ascertain *all* the causes of lost performance, and what adjustments, repairs, or replacement parts are required to bring back the performance to normal.

Apart from recommending a tune-up in cases of specific complaints such as those mentioned, it is in addition quite safe to recommend a tune-up in every case where a car has been driven 3,000 miles or more without having been tuned. The car owner may have no specific complaint, and more than likely will feel positive that there is nothing wrong with the car. That is because he has been driving the car continuously and therefore has not noticed the gradual decline in its performance.

To such an owner the service mechanic is perfectly safe in advising a tune-up with a definite promise of restoring the performance of the car in power, acceleration, and economy.

Fig. 4.—A CRYPTON ENGINE TESTER

This includes vacuum gauge for measuring engine vacuum, a compression gauge for measuring cylinder compression, voltmeter and ammeter, and various devices for ignition testing. (*Crypton Equipment Ltd.*)

The Technical Side of Engine Tune-up

The above introduction will help every service mechanic in studying the articles which follow in the form of a complete series, and which give the fullest information of how systematically to analyse the causes of lost car performance and to carry out such adjustments, repairs, or replacements as the tests made show to be necessary.

MODERN ENGINE TUNE-UP EQUIPMENT

There has been developed during recent years a considerable variety of specialised apparatus for systematically testing engines and electrical equipment. This equipment can broadly be styled as engine tune-up equipment, since its proper function is to enable a tune-up to be easily performed.

Tune-up can be applied to the engine itself, to the electrical or fuel systems, to the shock absorbers, or to any other mechanical or electrical operation on the car, because it means in every case restoring the original standards of adjustment.

Types of Engine Tune-up Equipment

Types of engine tune-up equipment as met with under average conditions in English motor-trade practice are represented by such equipment as the Crypton engine test and engine analysers, the Ford laboratory test set, Stromberg motor-scope, and the Potter analyser.

The service mechanic is apt to get somewhat confused because of the wide differences that at first sight seem to exist between the various types of equipment available. It should be recognised, however, that basically

all these various items of equipment are the same. They each consist of a number of standard instruments assembled in varying forms to provide an impressive and complete means of making mechanical and electrical tests of the car.

Briefly, all the various makes of equipment are made up of the following instruments:

A vacuum gauge for measuring engine vacuum.

A compression gauge for measuring cylinder compression.

A pressure gauge for fuel-pump testing.

A voltmeter for electrical testing.

An ammeter for electrical testing.

A sparkmeter for measuring sparking length of ignition high-tension systems.

A condenser tester for measuring charge and discharge values of condensers.

An ohmmeter giving a direct reading in ohms of the resistance of wiring and electrical circuits.

A motor-driven contact breaker, comprising variable-speed motor with make-and-break for testing ignition coils under variable speed conditions, and giving facilities for high-tension testing of moulded insulation parts.

A distributor syncroscope for accurately and visually indicating the performance of distributors.

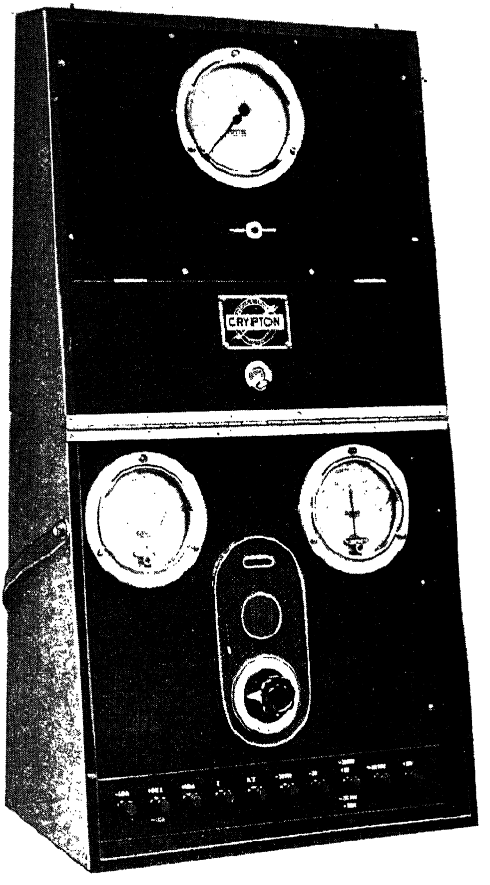


Fig. 5.—A SMALLER ENGINE TESTER

This includes a vacuum gauge, voltmeter, ammeter, and sparkmeter. (*Crypton Equipment Ltd.*)

Exhaust gas analysers for analysing the exhaust gas.

Provided these various instruments are each properly understood, there will be no difficulty in operating any particular make of equipment, since all that is required is a knowledge of the exact methods used to combine the various instruments and a knowledge of the switching operations, since very often two or more separate instruments are used from the same pair of terminals by means of a change-over switch ; frequently multi-scale ammeters and voltmeters are used, a switch being provided for each individual scale.

Later articles outline the following :

(1) The theory and application of the different instruments which make up the various makes of test equipment available.

(2) A systematic method of rapidly checking over a car to ascertain the mechanical condition of the engine and the condition of the ignition, carburation, and electrical systems.

(3) A more complete analysis for checking valves, valve gear, piston rings, cylinders, carburettor, fuel pumps, plugs, ignition timing, ignition coils, condensers, dynamo, starter, distributor, wiring, accessories, etc.

ENGINE TESTING WITH A VACUUM GAUGE

By S. G. MUNDY, M.I.E.E., A.M.I.A.E., M.I.M.T.

PRACTICALLY every item of modern tune-up equipment incorporates a vacuum gauge, and this is the most important single instrument fitted to the equipment.

Portable vacuum gauges are also available and are becoming extensively used.

In order to obtain the most satisfactory results from vacuum-gauge tests and adjustments, it is necessary that the theory and application of the instrument should be understood. In the hands of an operator skilled in the use of the vacuum gauge it becomes an instrument of considerable utility, both in determining faulty engine condition, such as poor valves or valve gear, in adjusting ignition timing and carburettors, and for testing carburettors, fuel pumps, ignition and electrical equipment, etc.

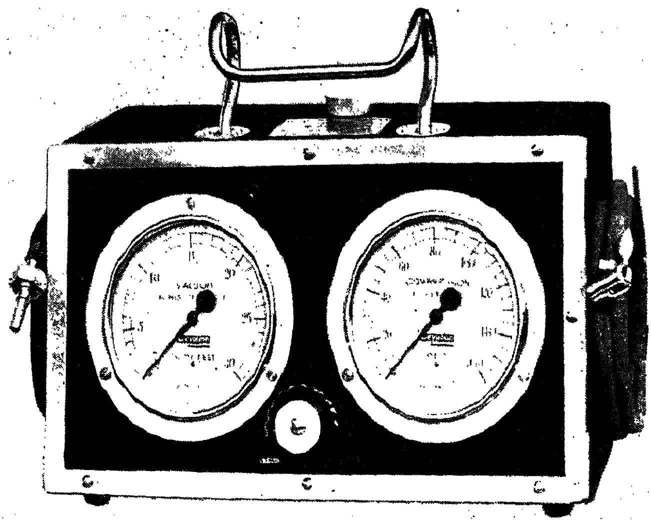


Fig. 1.—A PORTABLE ENGINE TESTER INCORPORATING A VACUUM AND A COMPRESSION GAUGE

(*Crypton Equipment Ltd.*)

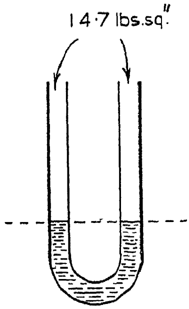


Fig. 2.—A GLASS U-TUBE CONTAINING A LIQUID

Note that the liquid levels are the same.

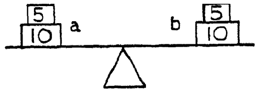


Fig. 2A.—THE LEVELS OF THE LIQUID IN FIG. 2 MAY BE REPRESENTED AS A PAIR OF SCALES WHICH ARE IN BALANCE

The weights a and b on the scales represent the weights of the columns of air approximately 50 miles high.

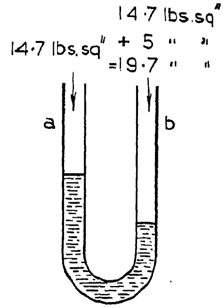


Fig. 3.—THE EFFECT OF APPLYING AN ADDITIONAL PRESSURE OF 5 LB. PER SQUARE IN. TO ONE SIDE OF THE TUBE

The Vacuum Gauge

As its name implies, the vacuum gauge is for the purpose of measuring vacuum. We are all familiar with vacuum in one form of application or another, and doubtless look upon it as being some form of space which is devoid of air, or else as a form of suction. This interpretation is, however, incorrect; "vacuum" is actually "pressure" (the exact opposite of what it is usually assumed to be), and better to understand the position it is advisable to consider pressures a little more fully.

The most common pressure with which we are familiar, and to which most reference is made, is "atmospheric" pressure. The air which we breathe, and which surrounds this world, does not extend indefinitely into space, but terminates somewhere between 100 to 200 miles above the earth's surface. Air has weight, thus the greater the thickness of a given layer of air or the greater the height of the air, the greater will be its weight.

Atmospheric pressure is taken as being the weight of a column of air approximately 50 miles high and 1 sq. in. in cross-section. The mean average weight of such a column is assessed at 14·7 lb., and atmospheric pressure is, therefore, spoken of as being 14·7 lb. per square inch.

Fig. 2 shows a glass U-tube containing a liquid. The two ends of the tube are open, and there will, therefore, be a pressure of 14·7 lb. per square inch on the liquid in each side of the tube. In consequence, the levels on each side of the tube will be the same. This is analogous to a pair of scales which are in balance, as shown in Fig. 2A.

Fig. 3 shows the effect of applying a pressure of 5 lb. per square inch to one side of the tube. The level of the liquid will be forced downwards

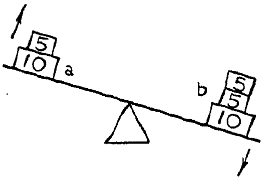


Fig. 4.—THE CONDITIONS IN FIG. 3, REPRESENTED BY A PAIR OF SCALES

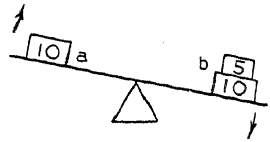


Fig. 5.—THE SAME EFFECT AS IN FIG. 4 CAN BE OBTAINED BY REMOVING WEIGHT FROM ONE SIDE OF THE SCALES (SEE FIG. 6)

on the side to which the pressure is applied, and upwards on the opposite side. The actual pressures to which the liquid is subjected will be—

Atmospheric pressure on side " a " of the tube.
Atmospheric pressure + 5 lb. per square inch on side " b " of the tube.

Again we see the analogy of the " balance " method as illustrated in Fig. 4, where an additional 5 lb. weight has been added to one side of the scale, causing this to drop and the other side proportionately to increase.

A moment's thought will show that the addition of extra pressure on side " b " of the pair of scales is not the only method by which this side may be made to go down. The same effect would be experienced if we removed some of the weight from side " a " of the scales, as shown in Fig. 5. By removing 5 lb. from side " a " instead of adding 5 lb. to side " b," we are getting the same results as were shown in Fig. 4.

Fig. 6 shows the application of this method to the liquid in the U-tube. An exhaust pump has been connected to side " a " and the pressure reduced by 5 lb. per square inch, which will cause the levels of the liquid to become the same as shown in Fig. 3.

Commercial Measurement of Vacuum

The standard laboratory-type instrument for the measurement of vacuum consists of a U-tube which contains mercury. The " unit " of vacuum is the " inch " of mercury, which is equivalent to 0·49 lb. per square inch.

The number of inches of mercury is determined by taking a direct linear measure of the difference between the levels in the tube.

Fig. 7 shows a mercury column registering 18 in. of vacuum. It will be known that there is no such thing as a perfect vacuum, since it is impossible to construct a container that can be completely exhausted, or the necessary exhaust pump to do it. There must always

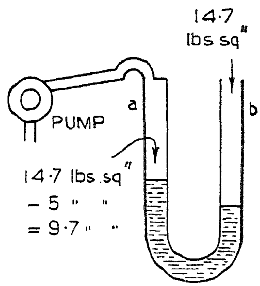


Fig. 6.—THE LEVELS OF THE LIQUID BROUGHT TO THE SAME POSITION AS IN FIG. 3

ONE SIDE OF THE BY 5 LB. PER SQ.

be a small quantity of air present in any vacuum, and thus there must always be a small pressure existing. This pressure can readily be determined. In the example, as illustrated in Fig. 7, the calculations would be as follows :

Since 1 in. mercury = 0·49 lb. per square inch, then—
18 in. mercury = 0·49 × 18 = 8·82 lb. per square inch, which is the amount by which the atmospheric pressure has been reduced. Subtracting this from atmospheric pressure gives 14·7 − 8·82 = 5·88 lb. per square inch, which is the actual pressure on the mercury in side "a" of the tube.

This shows, therefore, that a vacuum is really a pressure, but in order to distinguish it from normal pressures it is termed a *negative* pressure, meaning that it is lower than atmospheric pressure. Pressures above atmospheric pressure are termed *positive* pressures.

In considering these facts, and in making use of the vacuum gauge, it should be noted that where measurements are taken at considerable altitudes above sea-level it becomes necessary to allow for the reduction in atmospheric pressure due to altitude. The gauge reads *low* by approximately 1 in. for each 1,000 ft. above mean sea-level.

Connecting the Vacuum Gauge for Engine Tuning and Testing

For the purpose of engine tuning, and the location of faults resulting in poor engine performance, an accurate vacuum gauge with a clear scale reading should be used and connected to the induction manifold. The point at which the connection is made should be as close to the throttle as possible, in order that the whole of the air stream passing into the engine may pass the point of vacuum-gauge connection.

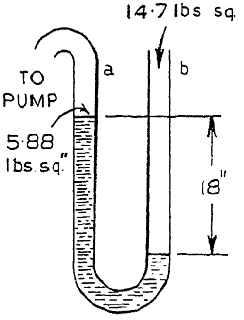


Fig. 7.—A
UM
OF VACUUM

In the case of engines having an existing connection already provided for the operation of windscreen wipers, ignition advance or retard units, or lubrication equipment, it is frequently possible to utilise this connection. Care must, however, be exercised, since in some ignition units, for example, the point of entry is on the carburettor side of the throttle ; also the disconnection of the unit may in some way interfere with the performance of the engine.

Where no point of entry to the induction manifold exists, it becomes necessary to drill the manifold at the correct point with a No. 30 drill, the hole being then tapped 3BA and plugged after use with a 3BA screw.

It has been queried from time to time whether this operation is in any way detrimental to the engine. It is not—and there is no need to remove the manifold for drilling; it is quite sufficient merely to cover both the drill and tap with thick grease in order to remove the majority of drillings. Manifolds are of two types—cast iron and aluminium; with the former the drillings are of granular structure, and in the event of any of them entering the engine the first explosion which occurs in the cylinder would result in the granules being carbonised. In the case of aluminium, the drillings come off in the form of turnings, and the final turning, made as the drill goes through, invariably turns back inside the manifold in the form of swarf.

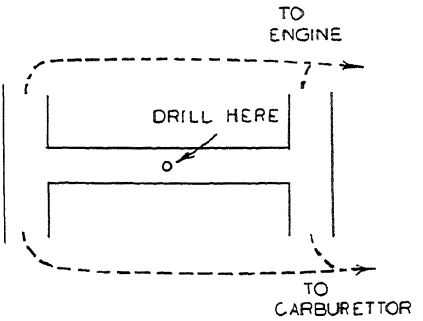


Fig. 8.—POSITION OF CONNECTION OF VACUUM GAUGE TO BALANCE PIPE OF INDUCTION MANIFOLD OF CAR FITTED WITH TWO CARBURETTORS

Another factor often overlooked in considering drilling the induction manifold, is the fact that there is only one possible point where trouble could arise due to the ingress of drilling particles. This is that they may be trapped between the valve and the valve seat, thus allowing leakage at this point. Fortunately, however, one of the uses of the vacuum gauge is to locate valve leakage, and in the event of such an occurrence the subsequent behaviour of the gauge will indicate what has happened.

Drilling for Dual and Triple Carburettors

With dual carburation systems it is necessary to drill both carburettors unless a balance-pipe is fitted; in this case the vacuum gauge may be connected to the centre point of the balance pipe, as illustrated in Fig. 8.

With triple carburettors it is usually sufficient to drill the centre carburettor, as illustrated in Fig. 9, although it may sometimes be found necessary to drill all three carburettors. In the case of triple units which do not offer a ready means of drilling the centre unit, and providing balance-pipes are fitted, the

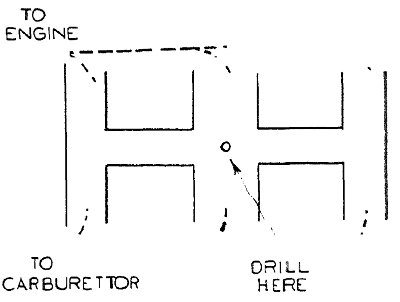


Fig. 9.—USUAL POSITION OF CONNECTION OF VACUUM GAUGE WHERE THREE CARBURETTORS ARE FITTED

An alternative is shown in Fig. 10.

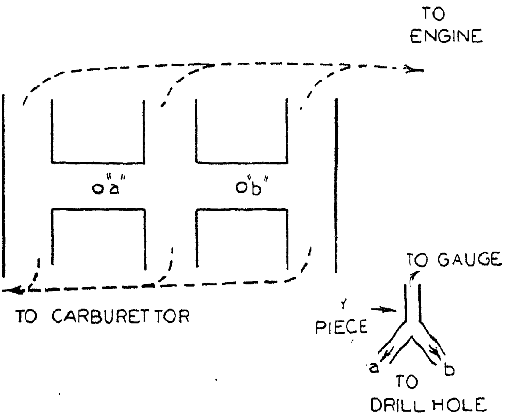


Fig. 10.—AN ALTERNATIVE METHOD OF VACUUM GAUGE CONNECTION FOR TRIPLE CARBURETTORS

The two points of connection are connected together and to the gauge by means of a Y piece.

centres of both pipes should be drilled and the two points of connection joined together and to the vacuum gauge by means of a " Y "-piece, as illustrated in Fig. 10.

The Theory of Operation of the Vacuum Gauge when used for Engine Tuning and Testing

In order correctly to interpret the behaviour of the vacuum gauge for tuning and testing engines, it is necessary to have a clear understanding of this theory of operation.

The basis upon which the vacuum gauge operates is best understood by considering Fig. 11, where " a " is the vacuum gauge, " b " a tank, " c " an exhaust pump, and " d " a valve controlling the ingress of air into the tank.

We will assume firstly that the valve " d " is half open and the pump " c " is running at a medium speed ; a certain reading will be recorded on the vacuum gauge. If, now, the valve "d" be opened further, the additional ingress of air into the tank will, providing the pump remains running at the same speed, result in a fall in the vacuum-gauge reading. The same result would have been produced had the valve " d " been left in its original position, and the speed of the pump reduced.

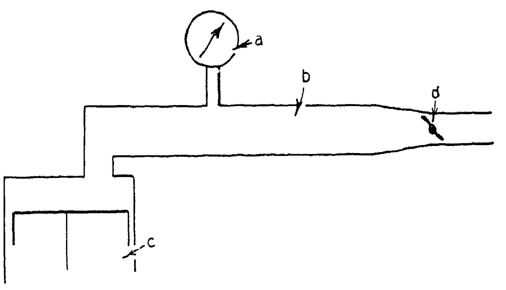


Fig. 11.—ILLUSTRATING THE OPERATION OF THE VACUUM GAUGE WHEN USED FOR ENGINE TUNING AND TESTING

If, on the other hand, we reduced the ingress of air into the tank by partly closing the valve " d " or by increasing the speed of the pump " c," a higher vacuum reading would have been

Let us now consider Fig. 11 as representing a car engine where " b " becomes the induction manifold, " c " the engine itself, and " d " the throttle. Two major differences will immediately be observed. Firstly, the vacuum in the manifold " b " will not be that due to a single cylinder. Secondly, the air-ingress valve " d " becomes the throttle and controls the speed of the engine, i.e. the speed of the pumping. Thus, by opening " d," not only is more air admitted to the manifold, but there is an increase in the rate at which the air is extracted.

It will, however, be found that a reading can always be obtained on the gauge irrespective of the position of the throttle. This enables us to apply the gauge at any speed of the engine, it being necessary only to set the throttle to the speed required and leave it set in that position.

Engine Tuning

The engine depends for its efficiency upon the completeness of combustion of the fuel supplied to it. This is the condition which the vacuum gauge must indicate if it is used for tuning the engine.

Let us revert to Fig. 11, and assume the engine is set at fast idling speed and that the gauge shows half-scale deflection. The effect of any adjustment made to the carburation system which results in a better mixture being obtained means—firstly, that more of the fuel being taken in by the engine is being used, and there is, therefore, less direct wastage ; secondly, that more power is being developed from the fuel, in consequence of which the pistons receive greater impulses when on the power stroke, *hence increasing the engine speed, despite the fact that the throttle has not been readjusted*. This increased speed or pumping action gives a higher vacuum-gauge reading. Thus, in order to tune any engine, it is necessary only to set the throttle and fix it in one position, and then carry out adjustments of the mixture until the highest steady vacuum reading is obtained.

The same considerations apply in ignition setting. The ignition is advanced or retarded until the spark takes place at the position which will result in the most complete combustion, giving the maximum power stroke ; thus, the maximum speed, the maximum " pumping action," and the maximum vacuum reading.

The effect of a mixture that is too rich or too lean, or an ignition setting that is too far advanced or too far retarded, will be a falling off in the gauge reading. There is only one optimum position, and that will correspond to the point of most complete combustion efficiency, when maximum power, speed, acceleration, and fuel economy are assured, all these conditions being represented by the highest *steady* vacuum reading it is possible to obtain.

Checking Mechanical Condition with the Vacuum Gauge

Apart from the use of the vacuum gauge in tuning engines where we adjust ignition and carburation, as described, to obtain maximum steady

vacuum reading, it is also possible to use the gauge to determine whether the engine is in a satisfactory mechanical operating condition.

The gauge is connected to the induction manifold, as previously described, but it is operated on the starter. The engine now operates directly as a vacuum pump. The vacuum gauge will indicate the "pumping efficiency" of each cylinder. The reading will vary with the position of the pistons—in other words, it will be proportional to the compression ratio.

In making this test we are concerned with getting an indication of any abnormal leaks in the engine, i.e. leaks past valves or piston rings. First of all we completely close the carburettor butterfly. Any other source of air leak into the induction system then becomes illegitimate (excluding certain cases where the design of the engine allows of leaks, such as drain pipes).

The vacuum reading which will be obtained will depend upon temperature, the compression ratio of the engine, and the existence of any illegitimate air leaks which may exist. The temperature can be rendered more or less constant if we test all engines hot. The compression ratio is known. We are therefore left with the unknown quantity of air leaks for any given speed.

If we were testing a single cylinder, the vacuum gauge would, when the suction stroke had ceased, drop to zero. In testing a multi-cylinder, however, we have another suction stroke which commences as the first is finishing. The vacuum reading will, therefore, be maintained constant if the suction force of the second cylinder and of succeeding cylinders is equal to the first. Therefore, when testing a multi-cylinder engine turned over by the starter, the vacuum needle can remain steady only if the successive suction strokes are equal, that is if all cylinders are uniform in their absence from illegitimate air leaks. If we had such an illegitimate air leak in the induction manifold, it would be common to all cylinders. Therefore the vacuum reading would be lower than normal, but would remain steady. If, however, any one or more cylinders had leaky valves, then the effect of this leak would be apparent only when the suction of that particular cylinder or cylinders was being measured; the result would be a momentary drop in vacuum—in other words, an irregular reading.

In using the vacuum gauge in this way, therefore, we are able to get an indication both of valve troubles which will cause an irregular reading, and air leaks in the induction system which will cause a low and steady reading.

DETECTING ENGINE FAULTS WITH THE USE OF THE VACUUM GAUGE

In the hands of a skilled operator the vacuum gauge provides a reliable and accurate method of diagnosing the engine for both mechanical faults and ignition and carburation troubles. The test should be carried out systematically, in the following order:

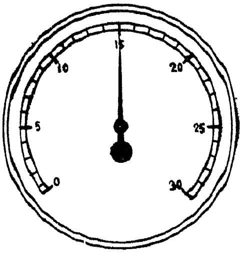


Fig. 12.—STARTER VACUUM

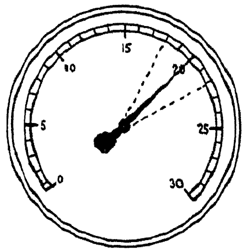


Fig. 13.—NORMAL VACUUM

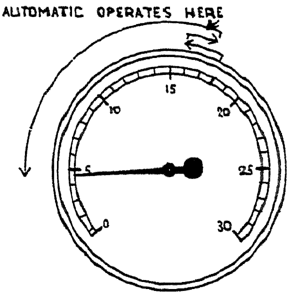


Fig. 14.—AUTOMATIC ADVANCE AND RETARD

VACUUM-GAUGE READINGS

1. Starter Vacuum Test (Fig. 12)

The engine does not run for this test, but it is essential that it be hot.

If the car is fitted with Startix, disconnect wires so that the unit is inoperative. If the car is fitted with auto-electric choke connected to the starting switch, this choke must be disconnected. Close the vacuum-gauge damper valve almost completely, and close the car throttle completely (no choke). Then run the engine by operating the starter for about 15 secs. If the vacuum-gauge reading is 15 in. or over, there is no leakage. If the reading is less than 15 in., check the inlet manifold and exhaust gaskets carefully. If there is no sign of a fault, loosen off the carburettor and insert a piece of cardboard or "hallite" between the carburettor and the intake manifold and tighten up. Then make a further test by operating the starter. If the reading is slightly higher than before, the carburettor is in order, but if there is a big increase it indicates carburettor leakage. If there is no increase at all, it indicates bad valve or manifold condition. It is wise to make the necessary adjustments before further checks are proceeded with.

2. Check Engine Vacuum (Fig. 13)

Having run the engine until it has reached normal temperature, set the throttle at a speed equivalent to about 10 m.p.h. Note the reading on the gauge. A modern high-compression engine in good condition should give an average vacuum reading of 18–22 in. The readings will vary slightly with the number of cylinders, and will also be affected by altitude as follows :

Engine	*Sea-level to* 1,000 *ft.*	1,000 to 2,000 *ft.*	2,000 *to*	3,000 *to* 4,000 *ft.*	4,000 *to*
Four cylinders	18 to 20	17 to 19	16 to 18	15 to 17	14 to 16
Six cylinders	19 to 21	18 to 20	17 to 19	16 to 18	15 to 17
Eight cylinders	20 to 22	19 to 21	18 to 20	17 to 19	16 to 18

Low-compression engines may give lower readings than the above, say 15–18 in. When testing four-cylinder engines, pulsating readings may be experienced, but these pulsations can be damped down by using the damper valve on the engine test. This damper valve is not required for six, eight- and twelve-cylinder engines.

On some test sets damper valves are not fitted, making it necessary to pinch the rubber hose in order to smooth out the pulsations. The provision of a damper valve on the equipment is a valuable refinement of design, and a much more positive and easy method of obtaining smooth readings.

The operator should not be confused if he finds the needle of the vacuum gauge going back and forth without indicating any definite condition—this simply means that troubles exist—probably a number of troubles which combine to give a peculiar reading. These troubles can be eliminated by further tests.

3. Check for Balanced Running

This test indicates the performance of each cylinder. For smooth running it is essential that every cylinder develops its full powers and is free from faults or irregularities.

Short-circuit the sparking plug on each cylinder in turn with a screwdriver. Note very carefully the change in the vacuum reading. Each cylinder should give an equal drop in vacuum, which may be from ½ in. to 2 in. The actual value of the vacuum drop is not so important as seeing whether the drop is uniform. Any cylinder which gives a lower vacuum drop than normal is probably faulty. A compression test will assist in locating the trouble.

If a very low drop of, say, less than ½ in. is obtained on all cylinders, this should not be accepted as satisfactory. It suggests an inefficient engine. If the drop is, say, 1½ in. on three cylinders, and only ½ in. on the fourth cylinder, then the latter cylinder is definitely faulty. The trouble may be due to—

(1) A faulty plug.
(2) Faulty piston or cylinder.
(3) Faulty valves or valve gear.
(4) Faulty tappet adjustment.
(5) Leaking cylinder-head gaskets.
(6) Plugs not screwed down.

If there is a small drop on all cylinders, this may be due to—

(1) Ignition trouble on high-tension side.
(2) Faulty inlet manifold.
(3) Back pressure, i.e. choked silencer.
(4) Leaky carburettor.

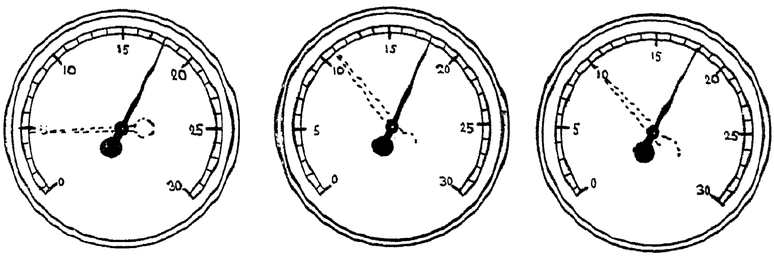


Fig. 15.—EXHAUST SYSTEM *Fig.* 16.—AIR LEAKS *Fig.* 17.—LEAKY GASKET

DETECTING FAULTS WITH THE VACUUM GAUGE

4. Automatic Advance and Retard (Fig. 14)

This test is more satisfactorily made with a laboratory syncroscope as fitted to complete engine analysers, but an approximate indication can be obtained with the vacuum gauge, as follows :

Rev. up the engine to a speed equivalent to about 30–40 m.p.h. The vacuum needle reading should drop back to a figure of about 4–5 in. Note the behaviour of the needle as it falls back. If the car is fitted with automatic advance and retard, when the automatic advance operates there should be an improvement in engine performance. This improvement should be indicated by a momentary increase in the vacuum reading ; thus, if the operation of automatic advance and retard is satisfactory, the reading will commence to drop back, after a point will increase, and then will fall back to its lowest reading.

5. Check Exhaust System (Fig. 15)

This test can be made at the same time as the check for automatic advance and retard. The vacuum needle, as the engine is revved up, will have dropped back to a low reading. When the throttle is released the needle should spring back quickly. If the return of the needle is sluggish, it is an indication of a choked exhaust system, i.e. choked silencer or damaged exhaust pipe, and the exhaust system should be inspected and the fault corrected.

6. Air Leaks in Intake System (Fig. 16)

This test is made with the engine running at idling speed. The test checks for leaks in the intake system, e.g. the inlet manifold gasket, carburettor, carburettor gasket, vacuum windscreen wipers, and tubing ignition control, auto-starting device, vacuum brakes, etc. The existence of a leak will be indicated by a reading 3–8 in. lower than normal and quite steady, but with a tendency to drop further, depending on the speed, the heat of the engine, and the amount of the leakage.

7. Leaky Cylinder-head Gasket (Fig. 17)

This will be indicated if the needle drops sharply from its maximum reading to 10 in. or lower and returns quickly to maximum. If the leak is between two adjacent cylinders, the drop will be much greater; a more positive test of this fault is by the compression check (No. 7).

8. Sticking Valves (Fig. 18)

The vacuum-gauge reading will drop intermittently two to five divisions. Sticking valves can be distinguished from leaking valves, as with the former the drop is intermittent, since it occurs only when the valves stick. Some manufacturers advise reaming of valve guides to remove gum deposit, which may cause this trouble.

The existence of sticking valves can be proved to the motorist by the application of a small quantity of penetrating oil. If this temporarily remedies the condition, it proves the need for valve reconditioning.

9. Burned or Leaky Valves (Fig. 19)

The vacuum-gauge reading will drop one or more inches from maximum. If only one valve leaks, the drop will be slow and at regular intervals, as this valve attempts to close. If more than one valve is faulty, the action will be much more frequent. If valve clearance is not uniform, the condition will be similar to burned valves. A reading below normal maximum can also indicate tappets which are evenly adjusted but have clearance which is less than standard.

10. Late Valve Timing (Fig. 20)

The main indication of late valve timing is labouring of the engine and overheating. Late valve timing will result in a gauge reading fluctuating between 5 in. and 10 in.

11. Weak Valve Springs (Fig. 21)

A positive indication of weak or broken valve springs will be given by the vacuum gauge. The speed of the engine should be steadily increased

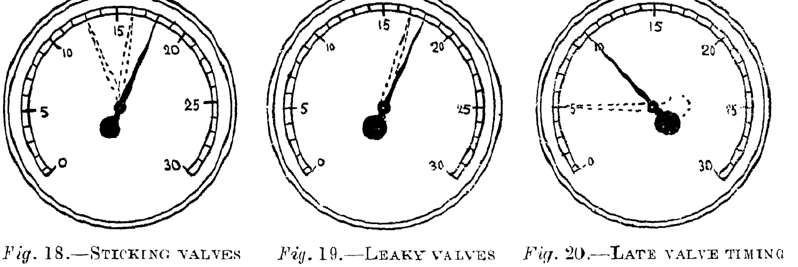


Fig. 18.—STICKING VALVES *Fig.* 19.—LEAKY VALVES *Fig.* 20.—LATE VALVE TIMING

DETECTING FAULTS WITH THE VACUUM GAUGE

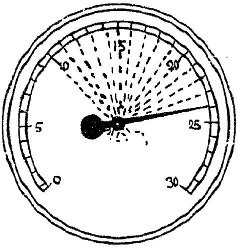


Fig. 21.—WEAK VALVE SPRINGS

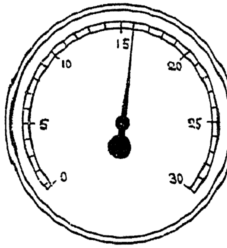


Fig. 22.—LATE IGNITION

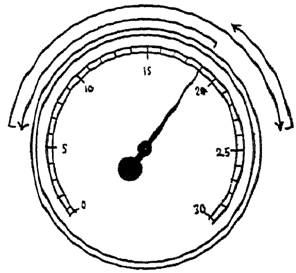


Fig. 23.—LEAKY PISTON RINGS

DETECTING FAULTS WITH THE VACUUM GAUGE

up to the highest speed at which it can be run without a load. If the vacuum reading fluctuates very rapidly between 10 in. and about 24 in., and the speed of the fluctuations increased with the speed of the engine, it is a definite indication of the existence of weak valve springs.

12. Late Ignition Timing (Fig. 22)

If the vacuum-gauge needle remains 2–3 in. below normal and the needle is almost stationary with the spark fully advanced, and if the engine labours, the ignition is late. The same condition can also indicate slightly late valve timing. To prove, check ignition timing as for Check No. 4.

13. Leaky Piston Rings (Fig. 23)

The compression check provides an indication of piston-ring leakage, but it is advisable to check this point whilst the vacuum-gauge tests are being made.

The engine should be run at idling speed and the throttle quickly opened to its full-open position, the engine being allowed to speed up to the highest point at which it can safely run. *The throttle should be closed quickly*, and if the reading jumps immediately to 5 in. or more above the normal idle vacuum reading, the piston rings are in good condition. A rise less than 5 in. will indicate loss of compression. This may be due to a worn bore or leaking piston rings, but before condemning the rings or recommending any work a test should be made by the compression check.

It is important to appreciate that the crankcase should be in good condition for this test, as a diluted or poor-quality oil will sometimes indicate loss of compression which does not actually exist.

14. General Ignition Tests (Fig. 24)

Sparkplug gaps which are defective, or improperly spaced, contact-breaker points which are burned or incorrectly spaced, weak ignition coils, leaking ignition cables, or corroded distributor caps will cause an

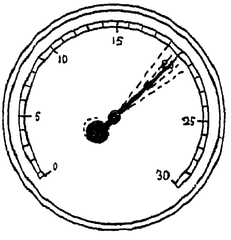


Fig. 24.—GENERAL IGNITION TEST

excessive vibration or chattering of the vacuum-gauge needle at approximately 1 in. above or below normal. High voltage can also indirectly cause this trouble because of its effect upon ignition. In the hands of a skilled operator the vacuum gauge provides a guide to the possible existence of ignition troubles and assists him in judging the necessity for determination of the exact point of the ignition trouble, which can only be carried out by the ignition-test facilities provided by the equipment being

CAR ELECTRICAL ACCESSORIES

By JOHN L. P. PINKNEY, M.S.A.E.E.

CAR electrical accessories are increased in number every year. Some are luxuries, while others become useful essentials affording easier and safer driving.

WINDSCREEN DEFROSTERS

The windscreen defroster promotes safety during winter driving, as its purpose is to prevent snow from freezing on to the windscreen. It is also a help to the screen wiper, since it allows the squeegee arm to wipe away the snow with ease and so lessens the strain on this unit.

Resistance Elements

Most defrosters work on the same principle, that is, the heating of resistance wire by passing a current through it from the car's battery. The heat dissipated from the resistance wire is allowed to warm up part of the windscreen so as to prevent snow sticking to it by freezing.

Construction of Defroster

One type consists of a metal box of about 1 ft. long by 2 in. wide and ½ in. thick, with one side open. Inside the box are stretched two lengths of resistance wire, connected in series and insulated from the box.

The voltage of the car's system determines the thickness of the wire used. This type of defroster is made to fit on to the bottom screen rail, so that the heat will rise up the windscreen.

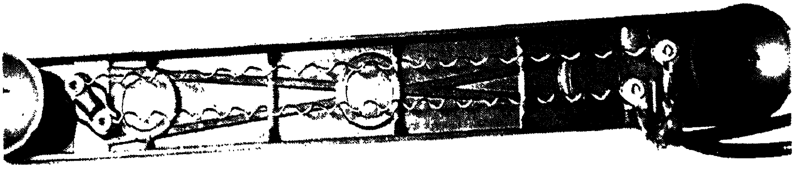


Fig. 1.—WINDSCREEN 1

The windscreen side of a defroster, showing the two lengths of resistance wire. The defroster is fixed to the screen by means of the two rubber suckers. The two lengths of resistance wire are in series when the switch is on, and when in the "off" position the series connection is open-circuited.

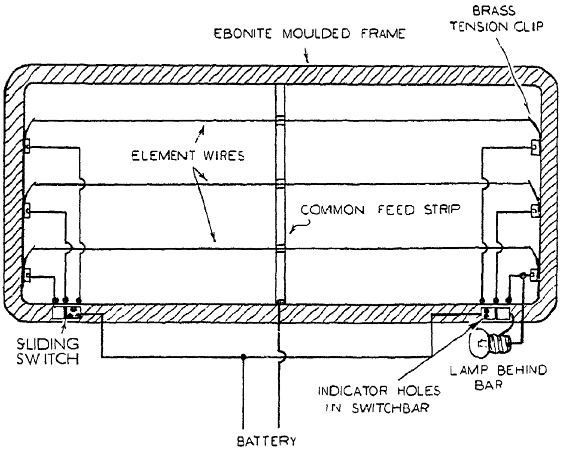


Fig. 2.—THIS SHOWS THE LAYOUT OF A DEFROSTER WHICH SPANS THE FULL LENGTH OF THE SCREEN

Each sliding switch selects from one to three elements on its half of the defroster. The switch bar has holes drilled through it. The number of holes showing corresponds to the number of elements switched on. Behind each switch bar is a small lamp which shines a light through the holes. A sheet of glass is fitted over the defroster to protect the elements and also to deflect the heat on to the screen. The heavy weight of this defroster is supported by clamps in addition to rubber suckers.

A Larger-type Defroster

model is made up from a light metal oblong frame of approximately 1 ft. by 9 in. Across the frame, but insulated by mica sheets, are stretched four lengths of resistance wire of a thicker gauge than the previous type, since there is about twice the length used. All the four lengths of wire are connected in series.

The frame is attached to the windscreen by means of four rubber suckers.

Selector Switch

A more refined type of defroster has a selector switch fitted in the framework so that one or more of the resistance wire lengths can be switched in or out of circuit. In this case, the wire used is of a finer gauge, so that each length is suitable for the voltage of the accumulator.

Indicating Device

An added improvement is an indicator, which tells at a glance the number of wire elements in circuit. This indicator is very simple. The sliding switch is painted white, and drilled in the framework are four holes, so that if there are, say, two elements switched on, there will be two of the holes showing white.

Precautions to be Taken

It is important that the defroster is not switched on whilst the car is stationary, otherwise damage to the windscreen may occur through overheating, since there will be no cooling wind on the windscreen. It should therefore be connected in the ignition circuit, so that it cannot be left on by accident.

Glycerine to be Used

If trouble is experienced by the falling off of the defroster or, for that matter, any other component fixed by means of rubber suckers, the trouble can be cured by using glycerine instead of water for sticking the suckers, as glycerine ensures an airtight joint and it does not dry up in the same way as water.

Burnt-out Resistances

Since defrosters work at a low temperature, there is no possibility of the resistance wire burning out, but in time the wire becomes more or less brittle and, if roughly handled, it is likely to break. To repair the break by twisting the broken ends together is both unsightly and unsatisfactory. The best remedy is to replace the entire defroster or send it back to the makers for repair, since to replace the resistance wire would require a knowledge of the grade of wire used, and this varies with different makers, although if this information can be obtained, it is a simple matter to replace the old wire with new of the same gauge.

Faulty Switch Contacts

In the type of defroster having a selector switch, the tension of the wiping contact blade must be sufficient to maintain a good contact with the studs, otherwise these will become pitted by the sparking that would take place.

Cleaning the Contacts

These contacts should be cleaned occasionally if they are accessible by means of sandpaper or carburundum cloth, but when they are in an out-of-the-way place, they should be cleaned by operating the sliding contact a few times.

ELECTRIC CLOCKS

A useful accessory for the dashboard is a clock; but how often is it found in working order? More often than not the main spring is either run down or else it is broken. A clock which requires no attention overcomes most of these troubles, and such a clock can be operated either by a separate dry battery or from the car's battery.

Operation of Clock

These clocks work by impulses given by means of an electromagnet. When two contacts come together, current passes through the winding of the electromagnet and draws up a soft-iron armature. Linked to the armature is a ratchet which gives a part rotation to a toothed wheel, which operates the hour and minute hands of the clock. The armature is then pulled back by a spring, ready for its next upward movement. These movements take place at regular intervals of a few seconds.

Clock Circuit

Needless to say, the circuit connecting the clock movement must be directly from the accumulator so that there is no possibility of having a switch in the circuit, otherwise the clock will show the wrong time. Such a connection can be obtained from the auxiliary fuses in the distribution box.

Test for Current Supply

If for any reason the clock refuses to operate, the first obvious test is to ascertain whether current is available up to the clock terminal and, if this is the case, then it will be necessary to remove the clock from the dashboard for a closer inspection.

Cleanliness Essential

Great care is necessary to make sure that dirt is kept away from the delicate internal mechanism, and for this reason the clock must not be opened out on the same bench as other components, such as dynamos and motors, are repaired.

Probable Faults

When the back of the clock is removed, the movement can be inspected and any obvious faults, such as a broken return spring, can be seen. The internal circuit is easily traced and can be tested out in the usual manner by means of a test-lamp or voltmeter. This test should verify whether the circuit of the electro-magnet coils is complete. The smallest spot of dirt on the contact faces is enough to prevent current passing to the magnet coils, but this trouble should not occur, since the movement is completely shrouded with the outer casing.

Stiffness of Parts

The drying up of the moving parts will impose enough friction to cause sluggish working or even to prevent the clock operating. This friction can be minimised by oiling the working parts.

The parts working face to face should be very slightly oiled with watch oil and not by any other, otherwise the trouble will be intensified. The oil should be applied by means of a sharp-pointed match-stick and not by an oil-can.

BATTERY CHARGERS

Although trickle chargers are not fitted direct to cars, they can be classed as an accessory, and a very useful one. They are made to deliver an output of 1 ampere at either 6 or 12 volts, and are invariably of the metal-rectifier type.

The charger is fixed permanently to the wall of the garage, and a twin flexible lead connects the charger to a special non-reversible socket fitted on the car's dashboard. The socket is connected to the positive and the negative accumulator terminals on the switchboard.

An all-night charge at 1 ampere is sufficient to liven up the battery to such an extent as to ensure easy and certain starting in the morning.

Do not Overload

It is important not to overload the rectifier by charging a 6-volt battery from the 12-volt tapping of the charger, otherwise the heat developed on the plates of the rectifier will destroy them in such a way that the output will be alternating current instead of direct current. Generally, there is a fixed resistance inside the charger to limit the output to 1 ampere when charging a 6-volt battery, and if the car is changed at any time to one having a 12-volt system, then it will be necessary to short out this resistance to obtain the 1-ampere output.

ELECTRIC CAR-WARMERS

An electric car-warmer provides comfort for the driver and the passengers of the car.

If the heating current is taken from the car's battery, the heavy discharge would soon exhaust it. The only practical proposition is to have a portable electric heater which can be connected to the electric supply in the home or garage, and when the heater is sufficiently hot to transfer it to the car. In this way, the stored-up heat is capable of supplying warmth for a considerable period.

Hot-water Radiator

A most satisfactory method of providing warmth to the interior of the car is by utilising the heat that has been transferred from the car's engine to the water in the radiator. This is achieved without interfering with the efficiency of the cooling system of the car.

Parallel Connected

The way by which this is done is to fit a small radiator between the footboards and the windscreen and to connect the two ends of the radiator coil to the top and bottom of the car's radiator, that is, in parallel with it.

Electric Fan

Fixed in the small radiator is an electric fan operated from the car's accumulator, so that the heat surrounding the radiator coils is blown forward.

The current taken by the fan is very small, being approximately one amp. A switch in the circuit controls the fan so that it can be switched off when the car is parked.

ELECTRIC CAR-HEATERS

Electric car-heaters are also used to keep the engine and radiator warm during cold nights, to prevent freezing of the water, and to enable the engine to be started up in the morning with ease.

Voltage of Heater

Such heaters can be supplied to work off the car's battery, and also from the electric supply up to 250 volts.

When possible, it is preferable to use the high voltage, since the current consumed at 12 volts is about 4 amperes, and so great a discharge from the accumulator during the night would discharge it to such an extent as to make the starter-motor sluggish in the morning.

These heaters are totally enclosed, to prevent any possibility of fire risks, and in the high-voltage type, the element is wound for a consumption of 100 watts.

Hot-water Circulator

A more elaborate type of heater is fixed in the water system and the heater connected to the electricity supply. The heat generated causes the water to circulate through the system.

PREVENTING SCALE AND "FUR" IN COOLING SYSTEM

It is well known that tap water leaves a deposit of fur in the water-cooling system, and if this becomes excessive the cooling action diminishes and the engine will run too hot.

Soft Water

One way to overcome this is to use water which has been softened by passing it through chemicals, but this is not always possible, especially when filling up at the wayside.

An Automatic Device

The scale- and "fur"-forming properties of hard water can be overcome by the Scale Buoy automatic device, which consists of a glass bulb containing a small quantity of mercury and inert gases. When the bulb is agitated in water small charges of static electricity are produced. The mineral salts in the water are polarised and prevented from depositing themselves as hard scale or fur. This device has been applied successfully both to domestic and industrial hot-water and steam plants, and there is a smaller unit for use in the cooling systems of motor-cars.

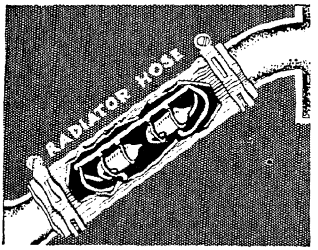


Fig. 3.—SCALE BUOY DEVICE FITTED INTO RADIATOR HOSE
(*Scale Buoys, Ltd.*)

The sketch on page 240 (Fig. 3) shows the Scale Buoy fitted into the radiator connecting hose. The motion of the car and the circulation of the water are sufficient to ensure that the polarising action is continuous.

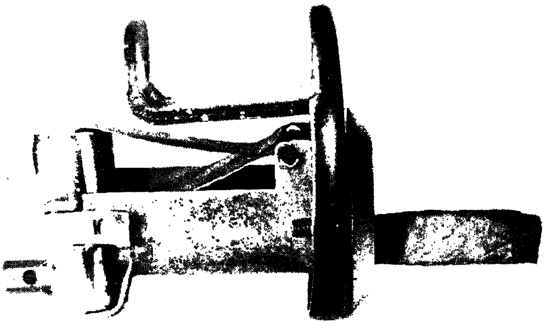


Fig. 4.—CIGAR LIGHTER

This shows a type which is automatically switched on by inserting the cigar or cigarette. The cigar lifts up a metal trap which then makes contact with a strip extension of one end of the element. The other end of the element is connected to the terminal seen on the left.

When the device is agitated in the water, it does not rid the water of its solids. The chalk and lime converted into another form does not leave a deposit on the sides of the water jacket but are kept circulating with the water.

Solids left in System

When evaporation takes place, it is only the water which evaporates and not the solids, so that in time a sludge will be left at the lowest point in the system. The amount of sludge will be so slight that there will be no necessity to remove it excepting after a very long period. If desired, it can be removed by opening the drain plug at the bottom of the radiator and swilling out the water system by means of a hose pipe.

ELECTRIC CIGAR LIGHTERS

Another luxury accessory is the electric cigar lighter, which enables the driver to indulge in a smoke with safety, as with this device only one hand is required for lighting the cigar or cigarette.

Three Main Parts

The lighter consists of three parts, namely: the base with its push-button, the heating element, and the element holder. The base is fixed to the dashboard and is connected up to the accumulator supply. The element holder is a moulding of bakelite which is easily slipped into the base.

The element is a flat strip nickel-chrome resistance spiral suitably insulated between turns, and the element is screwed into the hollow top of the holder.

Operation of Lighter

A few moments with the push-button pressed is sufficient to bring the resistance element to a red glow. The push-button is then released and the holder with its element can be slipped out of the base and used for lighting-up purposes.

Size of Cable

When fitting any of these accessories, it is important to use connecting cable of sufficient size to carry the current, otherwise voltage drop will prevent the component operating in its proper manner. Also, the use of too thin a cable will cause it to heat up, and this will soon perish the rubber.

Burnt-out Element

These lighters take approximately 8 amps. when switched on, and if left on for longer than necessary to bring the resistance element to a red glow, it will be burnt out. There is no remedy but to replace the element with a new one. This is simply a matter of removing the old element and fitting the new one in its place by means of a screw through its centre.

Another type of element is fitted on a M.E.S. cap, which is screwed into the holder in the same way as a flash-lamp bulb.

Some cigar lighters have a glass bull's-eye in front of the element. As this gets dirty, the operator cannot gauge the intensity of the glow, hence burnt-out elements. The bull's-eye is not easy to clean and is better removed. It is really a matter of gauging the time required to get hot enough, especially as the driver's eyes should be on the road and not watching the lighter.

Bad Contact

When the " wireless " type of lighter is dropped into its holder, the centre screw of the element makes contact with a brass strip on the holder, and in time this strip is bent too far back and so prevents good contact being made. To ensure good contact being made between the two components, it is necessary at times to bend the strip forward.

THE CARE AND REPAIR OF SUCTION-OPERATED FUEL-FEED TANKS

By E. W. KNOTT, M.I.A.E.

IN the British Isles, the best-known device of this type has been marketed for many years under the name "Autovac," and in spite of the competition due to mechanical and electrical pumps, large numbers are still in use, particularly on commercial vehicles.

On the Continent and in America, similar devices have been used, the main difference being that the Continental models invariably had much larger fuel-feed chambers, to avoid the drying-up of the fuel feed to the carburettor due to long spells of full throttle driving where the induction pipe suction was too low to lift the fuel from the tank to the inner chamber of the vacuum tank.

The Autovac has already been briefly described under the section entitled "Fuel Pumps," and this article proposes to go more closely into its repair and servicing.

Provided the top filter gauze is periodically cleaned and the drain tap at the bottom of the tank opened, the Autovac should have many tens of thousands of miles quite trouble free.

Stripping the Autovac

There is no need to remove the complete instrument from the vehicle, as the essential parts come away complete when the top flange is loosened.

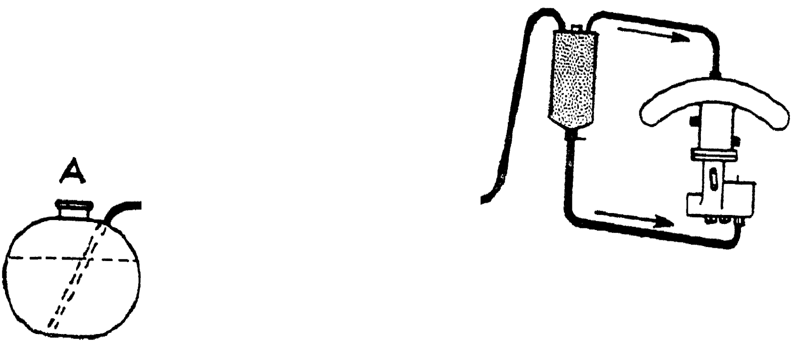


Fig. 1.—A PETROL-SUPPLY SYSTEM EMPLOYING VACU[illegible]ED, SHOWN DIAGRAMMATICALLY

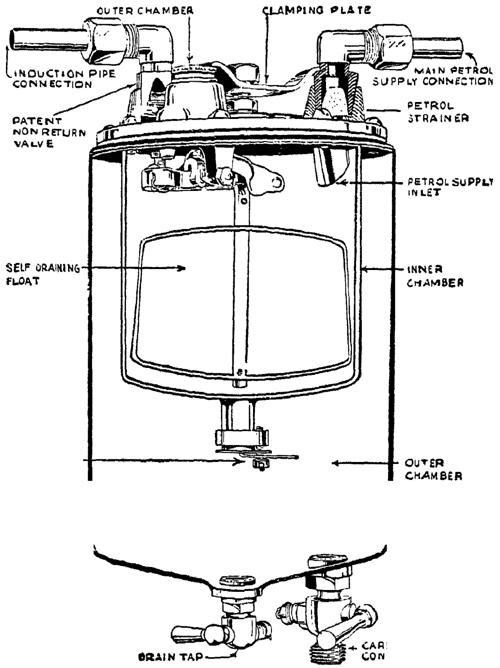


Fig. 2.—THE AUTOVAC, SHOWING INTERNAL CONSTRUCTION

To do this, undo the union nut of the main petrol-supply connection as well as the union nut of the induction-pipe connection, and spring the coned end of the pipes clear of the union elbows. Next undo the nut in the centre of the top cover and remove the three-eared clamping plate. It is always better to do this before removing the top cover.

An adjustable spanner can then be used to grip the two elbows, and by giving them a slight twist they will be loosened in their coned seatings and can be lifted out. If wished, the air vent plug can also be removed with a pair of pliers. All three should be cleaned with petrol, wiped dry, and put in a clean receptacle.

Next take out all the round-headed screws on the top of the Autovac, and the cover complete with the float and valve mechanism can be lifted off. Between the outer chamber and the top cover is an airtight joint washer of the Langite type, and great care must be taken not to break it. If the cover has not been removed for some time, there may be a tendency for the lid to stick in such a way that part of the joint washer will stick to the lid and part to the outer chamber, and a thin knife blade must be used to ease the joint until the cover comes away. It is not necessary, in fact undesirable, to separate the joint completely from both faces unless it is proposed to fit a new one.

Move the float up and down to see whether the change-over valve mechanism operates in a free and crisp fashion. If any pins are badly worn they should be replaced by new ones and the same applies to the valves, but they have an exceptionally long life. Wash free from all grit and check correct fit of valves by blowing into the induction-pipe connection boss whilst moving the float up and down for its full movement. With the float pushed up it should not be possible to blow air

past the valve except when the valve is pulled down.

Open the drain tap at the bottom of the outer container. The amount of water, dirt, etc., which collects even in a short time is astonishing, and if the tap has been neglected for some weeks of running, it may be necessary to clear it with a piece of wire. The inner chamber also rests on an airtight joint, and similar precautions regarding its damage must be taken as when removing the top cover. The drop valve at the bottom of the inner chamber should be quite free in action, and with the inner chamber empty should rest lightly on its seat. If the valve face is dirty or corroded, it should be carefully scraped clean, as on the fit of this valve in its "closed" position depends the good action of the Autovac.

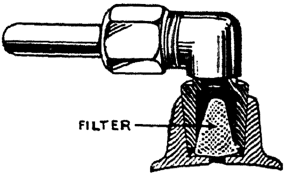


Fig. 3.—FILTER IN THE AUTOVAC

This will be found in the elbow of the Autovac that leads to the main petrol tank. Care must be taken to replace the filter gauze as shown.

Filter

When the main petrol connection elbow is removed, a conical gauze filter is exposed. This should be carefully lifted out and all dirt, fluff, etc., removed before replacing it. It is essential that the pointed end of the cone is on top, and it is advisable to clean this filter every three or four weeks.

Replacing the Cover

When replacing the cover, see that it is returned to its original position, i.e. with the air port corresponding with the hole leading to the outer chamber. This will also ensure that the elbows when replaced will be in correct relation to their respective pipes.

Having screwed all the screws down evenly and firmly, place the elbows and air vent in their cone seatings, push in the ends of the pipes, and tighten up the union nuts finger tight. The clamping bar can then be replaced and its nut lightly tightened down. Each elbow and the air vent should then be given a tap with a light hammer to fix it firmly in its seat. The clamping bar should then be properly tightened and finally both union nuts.

The Autovac is now ready for use, but if the outer chamber is quite empty, it is necessary to get some petrol into it before the engine will continue to run, even if there is enough left in the carburettor float-chamber to start it. To save using a possibly partly run-down battery, or the starting handle, it is advisable to put a teacupful of petrol in the outer chamber before putting on the top cover. If at any other time the Autovac runs dry, petrol can be poured into it after removing the elbow connected to the induction system, otherwise the Autovac can be primed

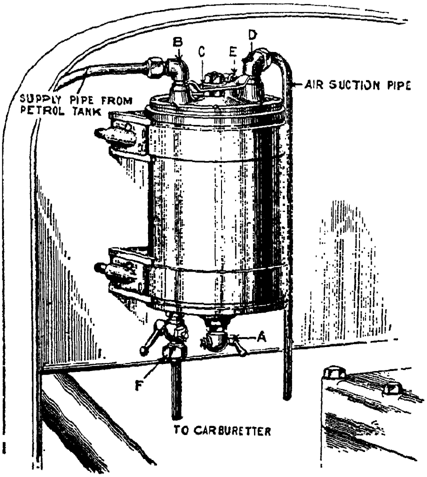


Fig. 4.—THE AUTOVAC MOUNTED DASHBOARD

by keeping the throttle shut and turning the engine over a few times until suction has lifted enough petrol to fill the inner chamber to a height where the float operates the valve gear and the petrol passes to the outer feed chamber. It is important that periodic inspection is made of the vent plug, the filter and the air vent in the main fuel supply tank, as well as the airtightness of the petrol and air lines and joints.

The float is of special construction in that it has a drain hole so located that in the event of fuel finding its way inside, the fuel is automatically exhausted when the valve gear "trips" to place the inner container in connection with the suction in the induction system.

There is on the market a suction intensifier in the form of a small venturi-shaped injector device. Air is drawn through it by the connecting pipe to the induction system, the throat of the venturi being connected to the Autovac. By this means, the suction on the Autovac is maintained to a satisfactory extent, although long periods of full-throttle running exist. As this device gives a continuous air leak into the induction system, it may cause the idling speed of the engine to increase. The slow-running adjusting screw at the throttle will therefore require to be altered and possibly the mixture adjusting screw also.

CAR-WASHING AND WATER RECLAMATION PLANT

By J. ROSE

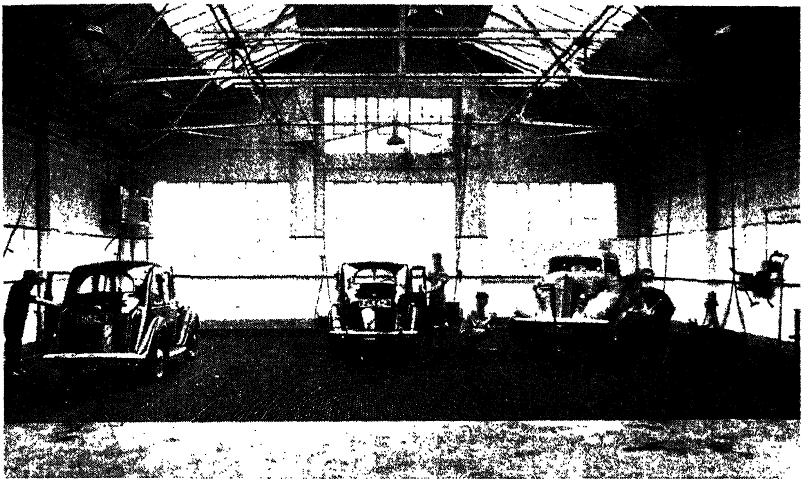


Fig. 1.—A MODERN CAR-WASHING FLOOR

Note the grill flooring, allowing both water and mud to drain away immediately. The water is used again after cleansing. The plant is described in the following article. (*By courtesy of the Car Mart, Ltd.*)

IN the past the washing of cars has been regarded by many as one of those necessary evils, but it is now becoming increasingly realised that a thoroughly cleaned car after repair is the sure way to increasing future business.

To further this end several different types of car-washing systems have been evolved, with the main object of producing the right results by the most economical methods.

An Actual Plant

Perhaps one of the most interesting of these systems is that installed by a large London service station, which incorporates a most ingenious scheme for reclaiming all used water, thus allowing the same water to be used again and again with a very big reduction in operating costs. The

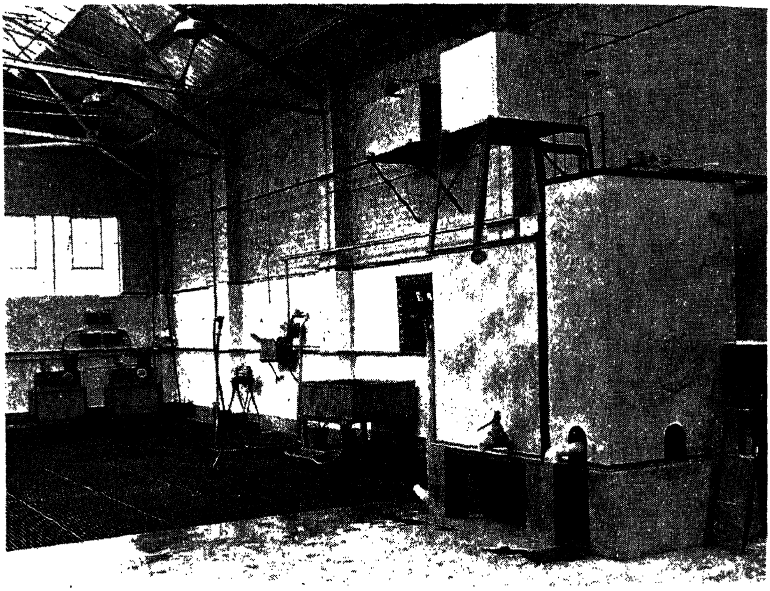


Fig. 2.—THE LAYOUT OF THE PUMP AND FILTER PLANT

The filter tanks are on the right. The necessary power washing pressure is supplied by means of the two electric motor-driven pumps on the left.

actual wash itself incorporates all that is best in modern practice, and covers an area of 38 ft. by 50 ft., enabling at least six cars to be cleaned at the same time without congestion.

Lighting, Cleanliness, and Efficiency

The surrounding walls are tiled to a height of 7 ft., thus allowing all cleaning to be carried out with the greatest of ease, which is so essential in these days when customers are inclined to associate, quite rightly, cleanliness with efficiency. Affixed to the walls, at a distance of 6 ft. apart and 3 ft. high, are large-power lamps designed to throw the maximum of light under the chassis, with the result that the operator has at all times a completely clear view of his work. These lights, coupled with large lamps spaced evenly overhead, enable car washing to be carried out always with the utmost efficiency.

The Water Supply

The power water supply is conveyed through Laycock overhead swing arms, which possess the advantage of allowing the hose to swing round to

any part of the car without trailing on the floor, at the same time permitting the operators to literally hang the hoses up on themselves by means of special fixings when not in use, and consequently saving great wear and tear, which is so often present when hoses are simply laid on the ground whilst the car is sponged down.

The necessary power-washing pressure is supplied by means of two Niagara washers, one of each being coupled to three hoses, enabling either of the two banks of hoses to be used according to the work on hand. In addition to the power wash there are also hoses supplied by gravity feed, and which are mainly used for sponging down, etc.

Compressed-air Points

There are also compressed-air points at accessible positions, so that they may be used as and when required, and although a comparatively small item, the installation of a small rubber-rollered mangle is of great assistance in wringing out leathers, etc.

Drainage for Water and Mud

The actual "floor" of the wash is covered by grill flooring, allowing both water and mud immediately to drain away, with the result that the old trouble of sediment being trampled into the car carpets is entirely eliminated. Underneath the grill flooring is literally a shallow pit, roughly 1 ft. deep, which is gently graded from all parts to a common sump at one side of the wash. This sump is actually the first stage of the water reclamation, and is approximately 4 ft. long, 2 ft. wide, and 2 ft. 6 in. deep, and is sectioned by means of a fine-mesh slide partition into two compartments, one being approximately twice as large as the other.

This section, when removed, allows for easy access and cleaning, and is primarily used for arresting the progress of the heavy sludge, which is removed from time to time by means of a special shallow truck expressly designed for this purpose.

Around the end of the sump which houses the small compartment a raised lip has been made, to prevent the possibility of heavy sediment entering this section.

Dirty-water Sump

By means of the shaped concrete floor, all water and sediment are directed into the larger compartment, which permits the water above to filter into the smaller section through the mesh partition, the main sediment then being trapped in the larger compartment. From the small compartment is taken a large suction-pipe, which delivers the dirty water into the actual cleaning plant. The operation of the pump controlling this suction-pipe is actuated by a float-operated switch, depending on the sump level to determine when it should come into operation. This position is pre-set and adjusted in such a manner that the sump will never

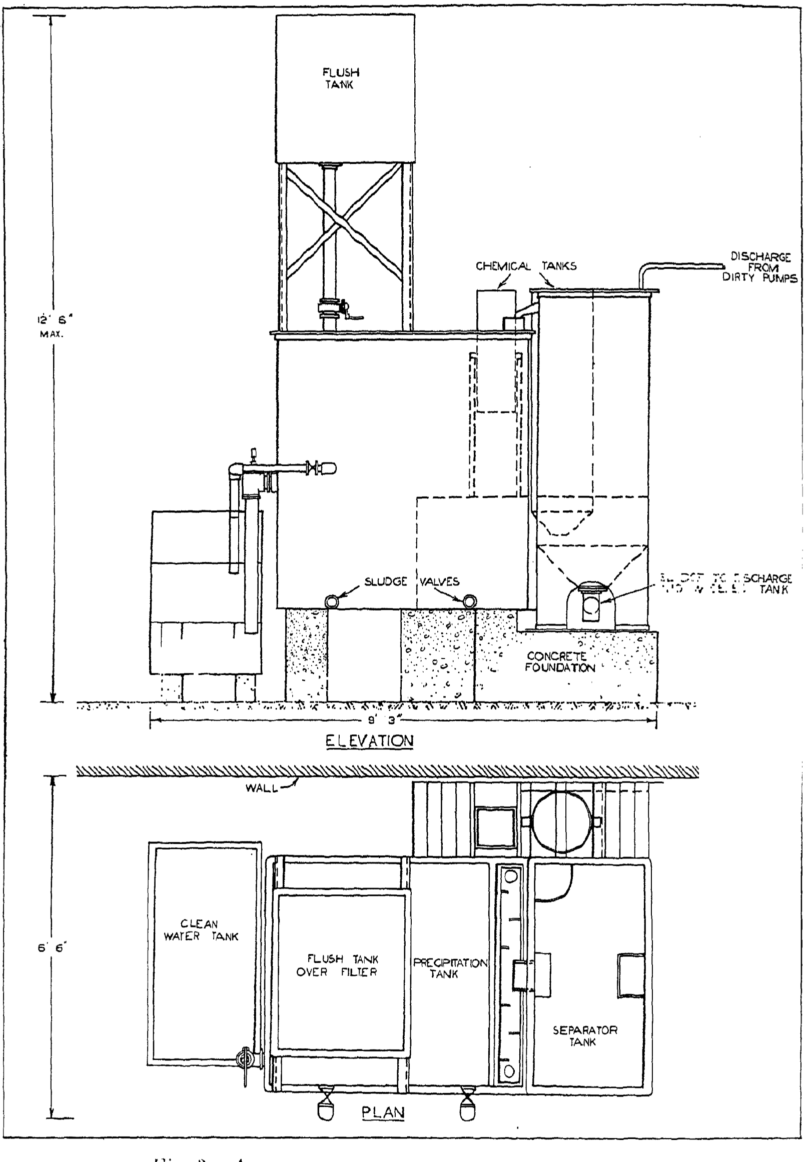


Fig. 3.—ARRANGEMENT OF CAR-WASH RECOVERY PLANT
(*Automatic Controls, Ltd.*)

overflow ; at the same time there will also be sufficient water to keep the mud, etc., present in a reasonably fluid condition, thus allowing for easy removal when necessary.

It will thus be seen that an entirely automatic operation covers the supply of dirty water to the reclamation plant.

Cleansing Tanks

After leaving the sump, the water is raised, by means of a pump capable of delivering dirty water, to a series of cleansing tanks which are so designed as gradually to remove more sediment as each stage is passed.

In the first tank the heavier particles and mud, in addition to most of the oily water, are trapped in such a manner that they can be subsequently drawn off and disposed of, this operation being necessary approximately once per day, assuming that the wash is working to capacity all the time. From this tank the water passes into a mixing trough, where the addition of chemicals causes precipitation of the lighter sediment, which subsequently discharges into the precipitation tank itself. Here the sludge formed by the combined action of the chemicals and dirt is allowed to settle out. The water next flows on to a sand filter, which ensures that grit or particles of solid matter cannot pass, thus obviating any possibility of foreign elements percolating to the pressure pumps. After being filtered through the sand, the water discharges into the reserve tank, in turn being pumped up to the header tank from which the necessary supply is drawn by the washing pressure pumps.

Naturally with such large quantities of sediment passing continually through the plant, care must be taken to see that regular inspection and cleaning are carried out according to conditions present.

Using the Water Over Again

The water so cleaned, whilst not presenting such a clear appearance as fresh tap-water, is in every way equivalent where the washing of cars is concerned.

Thus it will be seen that a complete cycle has now been achieved, the water exuded by the pressure hoses draining back to the sump and being reclaimed for further use.

The whole action of the reclamation plant is entirely automatic, all different cleansing operations being completely controlled by the flow of water passing through the system. The plant thus shows a great saving in water consumption, the same water being used continually with only a very small quantity of other water being needed as a make-up for small losses which are unavoidable.

This fact is very interesting when it is realised that literally thousands of gallons of water are actually wasted every day by innumerable concerns engaged in the washing of cars.

As a matter of interest, one well-known service station in London first

installed this system to combat the restrictions imposed by the Water Board during the drought of 1934, and subsequently showed such a considerable saving in operating costs that the plant was placed into permanent commission.

Costs of Installation and Running

The cost of installation of this plant is in the region of £750, inclusive of the power washers, swing arms, lighting, grill flooring, etc. As the depreciation of the equipment is practically nil, coupled with the fact that it is possible to deal with 8–10 cars if necessary per hour, the initial outlay is not quite so high as perhaps might at first be assumed.

Does Car-washing Pay?

Doubts are sometimes expressed as to whether car-washing pays. That it does not pay is to a certain extent true where the washing of cars is spread over a low number during the whole day, but in a concern where the flow of car-washing is practically continuous, the financial results obtained are definitely satisfactory.

Apart from the very definite psychological effect on customers who naturally become interested in this system on sight, there is a very definite saving on costs where the water supply is not dependent directly on the rateable value of the property.

Whilst in the main the majority of large garages using water supplies for car-washing are only charged on the rateable value of the property, it is possible that with the increasing use of water for car-washing purposes, in due course the authorities responsible may consider charging on a gallonage basis over and above a certain amount, and we believe certain provincial authorities already adopt this method.

AUTOMATIC IGNITION TIMING

E. T. LAWSON HELME

THE development of full engine power and the maintenance of maximum efficiency at all speeds and loads depend to a great extent on accurate ignition timing according to the conditions of the moment. As the conditions constantly change, it is essential that the timing should vary in unison, the ideal sought after being the maintenance of the fullest degree of advance the engine will stand without pinking, labouring, or backfire when starting.

Type of Petrol in Use and Ignition Timing

The type of petrol in use also has a bearing on ignition timing, as some fuels have a different "flame rate," which means that at the instant of spark and primary ignition, a fraction of time is required for the flame to spread from the vicinity of the spark to the whole compressed body of gas in the cylinder head before expansion takes place and resulting pressure on piston develops the power stroke. This fraction of time is almost immeasurably small, except in comparison with piston speed, when a

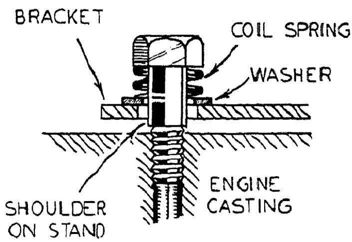
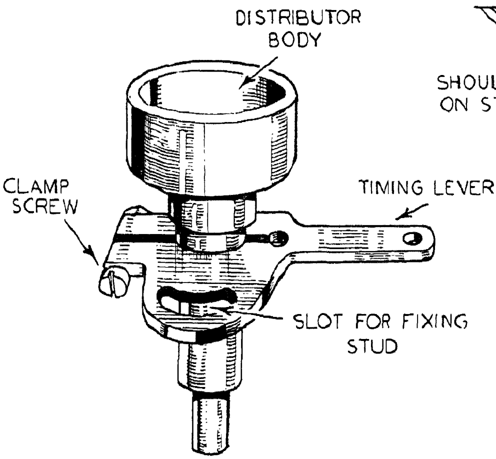
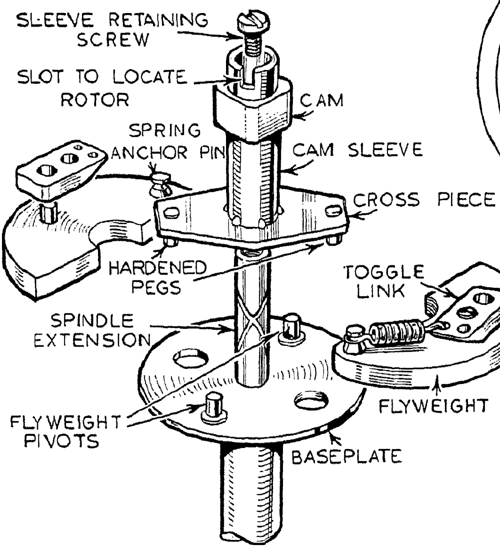


Fig. 1A (*above*).—THE FIXING STUD MOUNTING FOR MANUALLY CONTROLLED TIMING

The fixing stud retains the bracket and distributor body in position by means of a light spring and washer, whilst allowing the whole assembly to move within the limits of the stop.

Fig. 1 (*below*).—CONSTRUCTION OF MANUAL ADVANCE CONTROL FOR COIL IGNITION DISTRIBUTOR





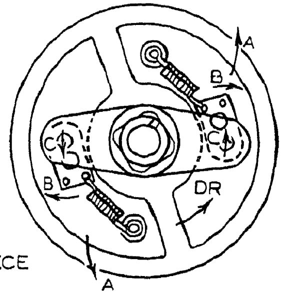


Fig. 2A (*above*).—P VIEW OF AUTO-AD-VANCE ACTION

Showing positions of the two control springs.

Fig. 2 (*left*).—DETAILS OF CONSTRUCTION OF AUTO-

spark timed to occur, say, $\frac{3}{8}$ in. before the top of the compression stroke in a fast engine at full speed, makes all the difference between sluggishness and efficient power, the early timing allowing the fuel to ignite and reach expansion coincidental with the commencement of "firing" stroke. This accurate variation of timing is beyond the capacity of simple hand control, familiar on early cars, and some form of automatic control—based on both engine speed and load—has now become largely standardised.

Manual Variation of Timing

Manual variation of timing of a coil ignition distributor is effected by movement of a bracket clamped to the barrel of the distributor body, the bracket having a lever extension which is linked to the hand control. A special form of fixing stud passes through a slot in the bracket, entering a tapped hole in the engine casting, and retains the bracket and distributor body in position by means of a light spring and washer, whilst allowing the whole assembly to move within the limits of the slot. Fig. 1 illustrates the principles of construction. Fig. 1A is a section of fixing-stud mounting.

Centrifugal Automatic Timer

Automatic timing variation according to engine speed is controlled by a system of centrifugal governing. Fig. 2 illustrates the details of con-

struction. The main distributor spindle passes through the barrel bushing into the upper body, where a circular baseplate is secured to and rotates with it. The upper end of the spindle is of smaller diameter and enters a steel sleeve integral with the cam, the lower end of the sleeve being secured to a cross-piece fitted with hardened pegs, as shown. Two pivot pins are riveted into the baseplate, and on each of these a lead flyweight with inset steel pivot bush is located. Each flyweight also carries a steel peg on which a toggle link is fitted. The peg is extended through to the underside and finished with a pounded head, so that it supports the weight and allows each weight to move easily about its pivot. The toggle links have each four holes. The centre hole is occupied by the pivot peg. The end hole receives one of the two hardened pegs of the sleeve cross-piece, and the remaining two small holes are for spring coupling, that nearest the spindle being used.

The whole assembly, as seen in plan, is shown in Fig. 2A, which also illustrates the positions of the two control springs not shown in Fig. 1. Each of these has one end connected to the toggle link, the other being hooked to the anchor pin on the flyweight-pivot bushing. Action of centrifugal control is as follows :

Operation of Centrifugal Timer

When starting and at low speed, the tension of the control springs keeps the flyweights in towards the centre, when the main spindle and cam-sleeve assembly rotate as one. Auto-timing of ignition is then in fully retarded position. Increase of speed or acceleration causes the flyweights to swing outwards on their pivots, the movement being transmitted via the toggle pegs to the toggle links. Arrows *A* in Fig. 2A show the direction of flyweight movement, and arrows *B* indicate the resulting displacement of toggle links. These, being linked to the pegs of the cam-sleeve cross-piece, cannot move out bodily with the flyweights, but turn about the centres of cross-piece pegs in the direction shown by arrows *C*.

The toggle link, therefore, acts like a lever and expands the control spring attached to it, the restraining effect of which is imparted to the flyweight concerned. The lever effect of the toggle link moves the cross-piece peg towards the flyweight pivot, this movement being in the direction of rotation " DR.," so that the position of the cam sleeve is advanced relatively to the main spindle.

Flyweight movement and cam advance are therefore directly proportional, greater speed producing further timing advance.

The Control Springs

The control springs are the most important components of the whole design, as they are the deciding factor in the performance curve of any one type of distributor. In some models it will be found that one spring is of light wire and is under slight tension when the mechanism is at rest,

so that its restraint is applied from starting speed. The other spring is of heavier section and has a slotted hook attachment, the effect of which is to delay its action until the flyweights have moved a few degrees against light spring tension. The second spring has then "taken up the slack" in its coupling, and its restraining tension is added to that of the first. The result of this arrangement is that a steep curve of advance is imparted at rising speeds up to a certain maximum, after which further increases in speed produce a more gradual advance of timing, due to the added restraint of both springs.

Eliminating Stiffness in Control Mechanism

Each type of distributor is fitted with control springs specially selected to suit the particular engine for which the distributor is intended, providing a curve or speed-advance ratio to conform with the engine designer's specification. Control springs are not interchangeable, and they should not be altered, reset, or tampered with in any way. The commonest cause of trouble in auto-advance mechanisms is stiffness, due to lack of lubrication. The sleeve-retaining screw, normally recessed in the cam head, has sufficient clearance to allow oil to pass to the sleeve bore and spindle extension, but if action is stiff and the engine shows signs of retarded ignition, the mechanism can be reached by removing distributor cap, H.T. rotor, retaining screws, and moulded contact-breaker base.

Before removing the latter, note position of terminal relative to body. The flyweight action can be checked by gently prising the weights apart and outward with a pencil, noting that toggle links swing round and sleeve advances. When released, the action should immediately return to retarded position. Failure to do so should not be attributed to weak springs until friction has been eliminated. Take out sleeve-retaining screw (a felt oil-pad is sometimes fitted in the cam recess enclosing screw head), but before lifting off cam sleeve note position relative to baseplate or mark cross-piece and base to correspond. With sleeve removed, flyweights, complete with toggle links and springs, can be lifted out. When all pivots, bushes, and wearing surfaces are clean and lubricated with light oil, assemble, seeing that pegs enter correct holes in toggles and that springs are hooked to "inside" holes in toggles. The outside holes are provided for use in distributors of opposite rotation.

Timing according to Engine Load

A further development of automatic timing control provides for correction according to engine load, supplementing control according to speed. For example, a car travelling at high touring speed may encounter a gradient, the added load of which will call for a greater throttle opening in order to maintain speed. The normal, fully-advanced timing due to automatic control will, however, remain proportional to speed, and the change in load may result in pre-ignition or pinking.

The inlet-manifold vacuum closely follows variations in throttle and load; and is used as the basis of automatic load control of timing.

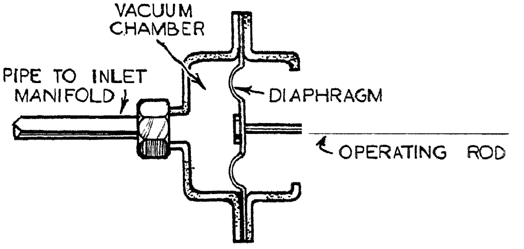
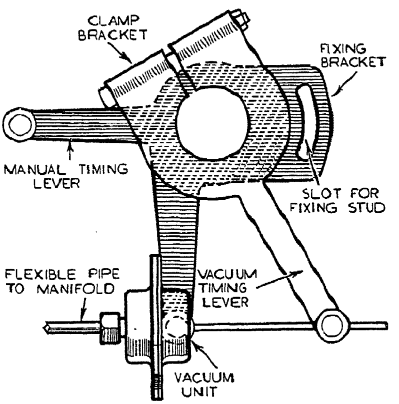


Fig. 3.—PRINCIPLE OF CONSTRUCTION CONTROL UNIT

The Vacuum-Control Unit

Fig. 3 illustrates constructional principles of vacuum-control unit. A vacuum chamber is connected via union and pipe-line to the inlet manifold. The two flanged faces formed by the vacuum chamber and bracket enclose a thin metallic diaphragm, sealing the chamber, and having an operating rod rigidly secured to its centre. The bracket is mounted on the engine casting, and the control rod is attached to distributor timing lever. The springiness of the diaphragm retains the movement in a central position at rest.

Fig. 4 illustrates the vacuum unit as assembled on a supplementary distributor mounting. The clamp bracket is rigidly secured to distributor barrel, and has integral automatic timing lever to which unit operating rod is attached. Unit is mounted on extension of fixing bracket, which also incorporates manual control lever and slot for fixing stud. Movement of manual timing lever therefore varies position of whole assembly within limits of fixing-stud slot, while movement of vacuum control varies position of clamp bracket relative to fixing bracket.



The latest development of this type of control takes the form of a vacuum unit incorporated in the distributor body. The contact-breaker base is designed to move about spindle centre, and is linked to unit operating rod, so that the whole of automatic advance is effected without relative movement of distributor body and engine casting. This is a great improvement, weight and wearing surfaces being greatly reduced and sensitivity to slight load changes increased, with resulting closer follow-up of timing to load-speed changes.

Operation of Automatic Load Control by Vacuum

The operation of automatic load control by vacuum is as follows :

When the engine is started and running idle at small throttle opening, the induction vacuum is at its highest. Resulting depression in the unit vacuum chamber causes exterior air pressure to force the diaphragm inward, pulling with it the operating rod and moving the distributor round against direction of rotation to advance timing. This ensures the maximum safe early timing under idling or light-load conditions. If the throttle is opened very gradually under light load, vacuum will remain almost unchanged, the engine being able to "accept" fully advanced timing, with extra advance by speed control, without pinking. Sudden opening of the throttle will cause a drop in induction vacuum, when engine speed cannot immediately increase in proportion, due to the load it is pulling. With fully advanced timing, this would cause pinking immediately, but the fall in vacuum allows the unit diaphragm to return to its original position, instantaneously retarding timing in relation to the load. Similarly, the progressive increase of throttle opening, necessary to maintain car speed up an incline, enables the vacuum unit to retard ignition in exact proportion to engine requirements.

In some late American designs the diaphragm action is supplemented by a spring, the tension of which is adjustable by a micrometer screw. The amount of delayed action imposed on vacuum control can, by this means, be accurately calibrated, to suit the grade of fuel in use or to compensate for carbonising and reduced engine efficiency.

With regard to the range of automatic advance, each distributor is set to its individual type of engine, the auto-advance varying from 15° to 40°. The average is about 15° to 25°.

LAMPS AND SWITCHES

By E. T. LAWSON HELME

BULBS

Filaments

FILAMENTS are usually in coiled form and placed to produce best results according to the purpose of the bulb. For headlamp use the filament is generally in straight-line or "U" shape, the resulting rays being reflected forward, and disposed in beam and spread formation by the lens. Extra support is sometimes provided by a third member, which secures the centre of the filament against sag or vibration, but is not connected to the circuit electrically.

Bifocal bulbs combine two separate filaments with a third (common) terminal support, this being connected to cap for return path to earth. Both filaments are usually "V" form, one being on the focal centre-line, and the other behind and below it, producing rays out of the focal centre, the resulting illumination being defocused and diffused to avoid dazzle (Fig. 1).

The Lucas-Graves filament arrangement has two filaments in line, one being shrouded by a metal cup placed beneath it, so that all downward rays are intercepted and only the upward rays are reflected. This prevents upward glare and the resulting dazzle.

Bulb Caps

Bulb caps are now largely standardised in dimensions and types. Fig. 2 shows common patterns on British and American cars.

The S.C.C. cap (*A*) is the most popular type, one filament lead being soldered to the centre contact pad and the other to the cap for earth-return circuit. The American version (*B*) has a longer barrel, and standard British caps will not interchange with it because of depth of holder and globe contour.

The S.B.C. (*C*) is the earlier form of cap, with two contact pads, each connected to one filament lead, no earth connection being made in single-filament bulbs. The same cap is used on bifocal and dual-filament bulbs, the latter having an additional filament of low wattage to provide "parking" light, seldom used now—in which cases the live feed to each filament is soldered to one of the two pads, the common (earth) lead being connected to the cap.

The special Bosch B.C. cap (*D*) is connected in this way, the cap being larger than the S.B.C.

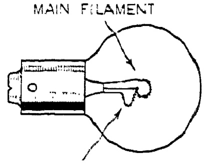


Fig. 1. A BIFOCAL BULB

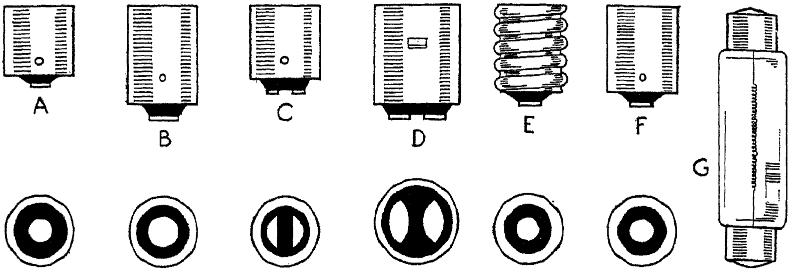


Fig. 2.—TYPES OF BULB CAP COMMON BRITISH AND AMERICAN CARS
A, S.C.C. cap. *B*, American S.C.C. cap. *C*, S.B.C. cap. *D*, Bosch B.C. cap. *E*, M.E.S. cap. *F*, M.C.C. cap. *G*, festoon bulb.

and provided with flat projections of unlike width to engage the slots in the bulb holder. One projection being wider ensures that the bulb can be inserted only in the correct way. Other caps have pegs placed 180° apart.

The M.E.S. cap (*E*) has a single pad and earth return to cap, and is screwed into the holder. A miniature bayonet cap (M.C.C. type), shown in (*F*), is used on panel lamps as an alternative to the M.E.S.

The festoon bulb (*G*) has a tubular globe with a cap at each end to which filament leads are soldered.

LIGHTING-SWITCH CONTROL

British lighting legislation compels the use of side and rear lamps at all times within lighting hours, whether headlamps are in use or not. Control is usually centralised in a single combination switch enabling side and rear alone, or side, rear, and headlamps to be used. Subsidiary control of headlamps—i.e. change-over from "driving" beam to "dipped" beam, or nearside reflector dipped with offside lamp switched off—is effected through the combination switch or an additional switch, with important differences in the circuit arrangement. In some cases headlamp control is effected entirely through a separate switch fed via the "side-rear" switch.

Lucas S.L.C.1 Switch

Fig. 3 illustrates the Lucas S.L.C.1 switch as wired to sides, rear, and a pair of bifocal headlamps. This switch is designed for fitting at the base of the steering column, operated by a handle on the wheel centre, a rod conveying motion through the hollow steering column to the switch action ; and has a rotary contact member with a transversely-grooved drum, two flat springs with curved ends falling into two opposite grooves simultaneously as the rotor is turned, providing a means of locating and holding the contact assembly in each lighting position.

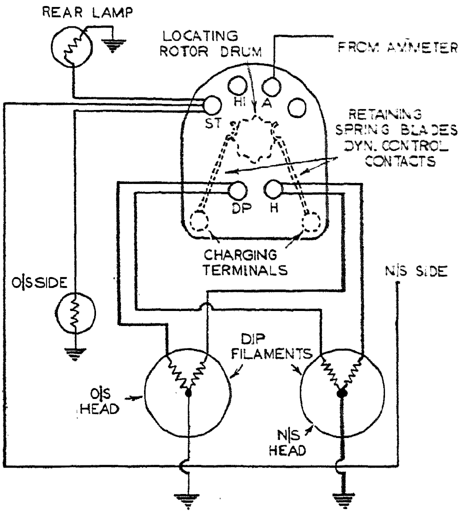


Fig. 3.—LUCAS S.L.C.1 SWITCH, AS WIRED TO SIDES, REAR, AND A PAIR OF BIFOCAL HEADLAMPS

The insulated base has a number of brass studs inserted flush with the surface, each being connected to a terminal outside the base, and the contact assembly comprises a set of springy brass fingers riveted to an insulated ring secured to the drum. As the latter is turned, the fingers bridge the terminal studs in turn, the combinations provided being shown diagrammatically in Fig. 4. In "off" position all lamp leads are dead. In "side" position, side lamps and rear lamp are alight through terminal *ST* being bridged to terminal *A* (battery feed via ammeter). In "head" position, sides, rear, and headlamps driving filaments are alight, all these studs being bridged to *A*. In "dip" position, sides and rear remain alight, driving filaments are out, as *H* terminal is no longer contacted, while the dipped-beam filaments are alight, "dip" terminal being in contact.

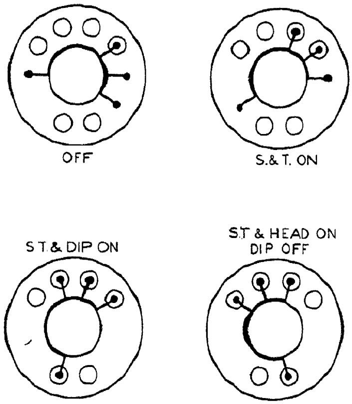


Fig. 4.—OPERATION OF LUCAS S.L.C.1 SWITCH

Lucas P.L.C. Switch

In Fig. 5, a circuit is shown controlled by a Lucas type P.L.C. switch, designed for panel mounting and direct manipulation by lever. This switch combines lighting, ignition, and charging control in one unit, but we will confine ourselves to the lighting terminals.

A ring of studs inserted in the insulated back are integral with the exterior terminals and a spring-contact assembly provides the combinations as before.

The circuit is that of a three-lamp set, where headlamps, placed in the required position, also serve as side lamps. In the "side" position, the

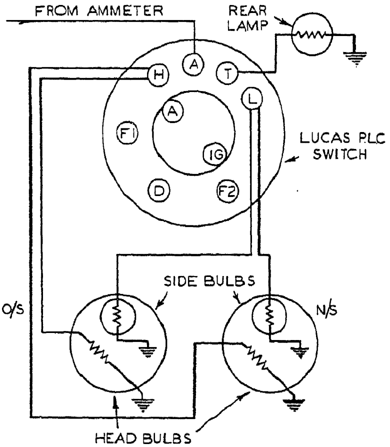


Fig. 5.—CIRCUIT CONTROLLED BY LUCAS TYPE P.L.C. SWITCH

small auxiliary "side lamp" bulbs fitted in the headlamp reflectors are fed from the terminal *L*, while terminal *T* feeds the rear lamp. In the "head" position, terminal *L* is off contact, while terminal *H* becomes alive, when "side" bulbs are out, and the headlamp bulbs are lighted, terminal *T* remaining alive to feed the rear. Terminal *L* on all P.L.C. switches is used only on three-lamp circuits.

Dipper Circuits—Five-lamp Set

The arrangement of the switch with a five-lamp set is depicted in Fig. 6, where sides and rear are connected to terminal *T*, terminal *L* is unconnected, and terminal *H* is the common headlamp feed. This circuit also includes a standard Lucas E.D.5 dipper reflector unit, with contacts controlling offside headlamp, by far the most common layout on modern popular cars.

The following points should be carefully noted: a single cable runs from P.L.C. terminal *H* to terminal *Pos* of the dipper unit, this being used as a junction for the short lead to the nearside lamp holder, and also the short wire bridging terminal *Pos* to terminal *R*. From this point, current flows through the dipper solenoid winding, via closed dipper contacts to fuse and terminal *Dip*, and thence through wiring and closed dipping switch to earth, returning to battery.

As the solenoid becomes electro-magnetic, the plunger is drawn sharply in, when the striker peg engages the lifting pad and raises the two upper contact arms, causing them simultaneously to break circuit with the lower contacts. The dipper contacts separate and the solenoid current is deflected through the resistance, which reduces its value to a degree just sufficient to retain the movement in the dipped position. At the same time, the "lamp" contacts separate and the feed to the offside headlamp—from *Pos* via contacts and wiring—is interrupted. It will be noted that the dipper is operative only when the headlamps are switched on, the feed to lamps and dipper being common. If the headlamps are switched off when the dipper is in use, the dipper returns to normal position, its current being cut off; while switching on the headlamps with the dipping switch closed causes the dipper to operate.

Switch-feed Arrangement

This circuit is designated "live feed," to distinguish it from the alternative arrangement—known as "switch feed"—shown in Fig. 7.

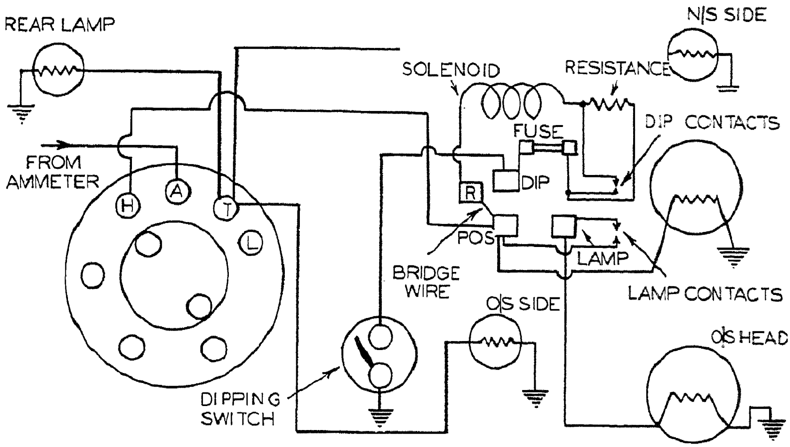


Fig. 6.—Arrangement of switch with a five-lamp set—"live" feed
This circuit also includes standard Lucas E.D.5 dipper reflector unit.

In this case the dipper control is incorporated in the main switch, the layout of which follows the lines of the S.L.C. shown in Fig. 3. It is customary in this arrangement for the offside lamp to be controlled direct from the main switch, and not through the dipper "lamp" contacts. The feed to the nearside lamp only is wired to terminal *Pos*, while the feed to dipper unit is wired to terminal *Dip*. The bridge wire is eliminated between terminal *Pos* and terminal *R*, the latter being directly connected to earth in the lamp body. Terminal *Lamp* is not required. When the switch is in "head" position, the nearside headlamp bulb is fed from main-switch terminal *H.1* and the offside bulb from terminal *H*. In the "dip" position *H.1* remains alive, but *H* is off-contact and the offside lamp goes out, while terminal *D*—becoming "live"—feeds the dipper, direct return to earth completing the circuit.

Dipping Circuit for Three-lamp Set

The use of a dipping reflector with a three-lamp set calls for special provisions to maintain the offside light required by law when the dipper is in use. Each headlamp is provided with a "side-lamp" bulb in addition to the main bulb, these being controlled from a P.L.C. switch through terminal *L*, as shown in the circuit of Fig. 5. A special form of dipper unit is used, as shown in Fig. 8, with an additional contact blade fixed above the upper arm of the "lamp" contacts. It should be noted that the four unit arm terminals are differently connected and marked, the *R* terminal now being *S*—a junction terminal with no connection

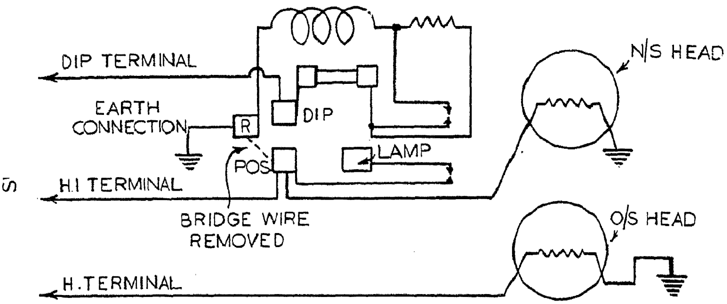


Fig. 7.—" SWITCH " FEED HEADLAMP CIRCUIT

In this case the dipper control is incorporated in the main switch, the layout of which follows the lines of Fig. 3.

to the dipper circuits, but connected to the additional contact blade, wiring to both " side " bulbs, and wiring to P.L.C. terminal *L*. Terminal *NH* is connected to upper " lamp " contact, nearside head bulb, dipper feed, and wiring to P.L.C. terminal *H* ; terminal *O H* connects offside head bulb and lower-lamp-contact only, while terminal *Dip* remains the dipper return to earth via dipping switch, as in the orthodox layout. With P.L.C. switch in " side " position, current flows to terminal *S* and feeds both side bulbs. When the P.L.C. switch is in " head " position, its terminal *L* is off contact and side bulbs go out, but terminal *H* is live and current flows to terminal *N H*, feeding nearside head bulb direct and offside head bulb via " lamp " contacts and terminal *OH*. When the dipping switch is closed, current also flows round solenoid winding,

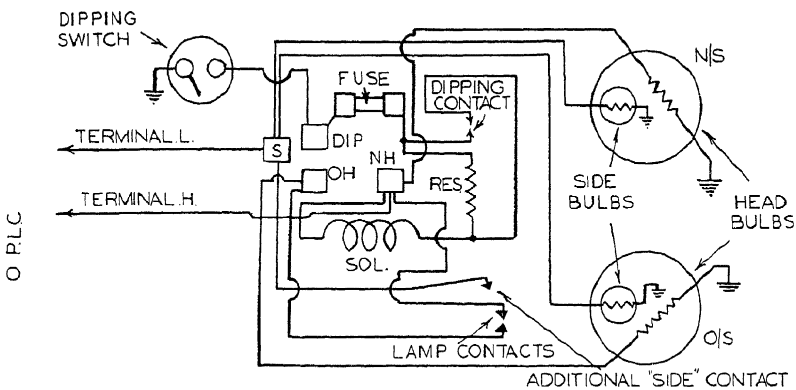


Fig. 8.—CIRCUIT FOR DIPPING REFLECTOR WITH A THREE-LAMP SET

through dip contacts—which the plunger separates, inserting resistance in series—via fuse to terminal *Dip*, wiring, and switch to earth. As the dipper operates, the lamp contacts are also separated, the offside head bulb goes out, and the upper "lamp" contact touches the additional contact blade when current flows from terminal *NH* to *S*, feeding both side bulbs. Thus, when dipped, the offside head goes off and side comes on, nearside head remains on and side also comes on.

In the latest design, exemplified by the 1939 Morris "8" Series E cars, a standard dipper unit is used, both side bulbs being wired direct to P.L.C. terminal *T*, as in five-lamp sets. When head bulbs are switched on the sides remain alight in each lamp, and when the dipper is operated, offside head goes out and nearside head is dipped, both side bulbs remaining alight. Thus, except for housing the side and head bulbs in one lamp on each side, the arrangement is identical to five-lamp practice, and the P.L.C. terminal *L* is not wired.

LAMP FOCUS

If a lamp is to give the maximum efficient illumination, correct focus of the bulb in the reflector is essential. The shape of the reflector is parabolic, the object of this being to ensure that rays of light impinging on its surface from the focal centre are reflected forward horizontally to constitute a parallel beam of great intensity.

Bulb behind Focal Centre

If the filament is placed behind the correct focal centre, its rays meet the reflector at too narrow an angle to the surface, and the resulting beam is spread sideways, leaving a dark spot in the middle of the beam.

Bulb in front of Focal Centre

With the filament forward of the correct position, the incidental rays describe too wide an angle to the reflector surface, and the beam converges inward, providing a conical pencil of light to a point where rays cross, and a converging beam with dark centre beyond. When the bulb is correctly focused the beam remains parallel for a considerable distance ahead.

Side illumination is obtained by direct (unreflected) light from the bulb.

Shape of Filament

The shape of filament is also important. For deep reflectors, an axial straight filament gives the best result, while in shallow types the filament should be V-shaped or restricted as nearly as possible to the ideal point of light. This pattern is commonly used in spot-lamps, where a penetrating pencil of light is aimed at, side illumination being of minor importance.

Fig. 9 shows focusing principles.

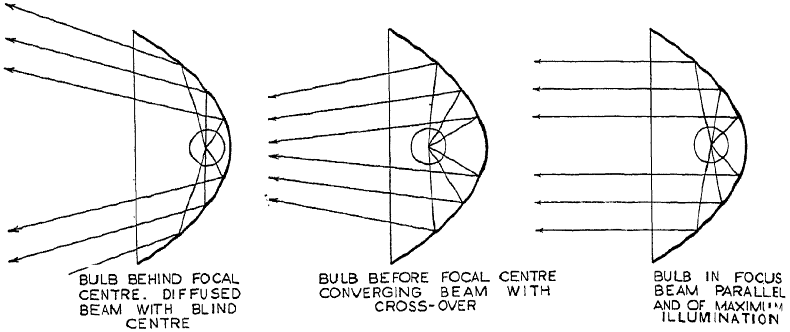


Fig. 9.—PRINCIPLES OF FOCUSING

ANTI-DAZZLE DEVICES

Apart from the dipped beam, by means of bifocal filaments or dipping reflectors, elimination of dazzle is achieved very effectively in the various designs of "pass lamp" now in use. The main objectives are the cutting off of all upward rays and the flattening and broadening of the beam. Cutting off all upward rays is effected by shrouding the downward filament rays, as in the Lucas-Graves bulb, and the use of a duo-focal reflector as in Lucas F.T.37 and F.T.57 lamps, the "Trippe" driving lamp, and other types. Flattening and broadening the beam is achieved by the use of fluted lenses and forward shrouding of the bulb as in the Lucas F.T. and P.100 lamps.

Duo-focal Reflector

Fig. 10 is a sectional view of the F.T.37 lamp, showing how the reflector is made with the upper half deeper than the lower half, although the whole reflector is actually pressed out in one piece. The position of the bulb filament is such that it is in the focal centre of the lower half but forward of the focal centre of the upper half. The lower half therefore casts forward a parallel beam of semi-cylindrical shape, while the upper half produces a converging downward beam. A metal cap attached to the cross-piece in front of the bulb intercepts all direct rays above the horizontal. The light is concentrated in elliptical form below the horizontal axis, with plenty of side spread, but no upward beam. In the F.T.57 a fluted lens assists the sideways refraction of light, tending to spread the beam fanwise towards the roadsides.

SERVICING INFORMATION

The following hints will be of assistance in locating and rectifying lighting and lamp-circuit defects :

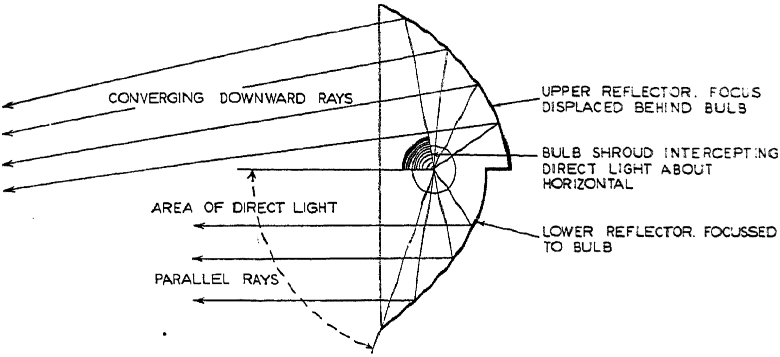


Fig. 10.—SECTION OF DUO-FOCAL REFLECTOR (F.T.37 LAMP)

Poor Illumination

Poor illumination may be due to old, discoloured bulbs, high resistance in series causing voltage drop, faulty battery, or bulbs of incorrect type. To check earth connections for conductivity, hold a length of cable in contact with the lamp body, and clean metal on the chassis, noting any increase of light, which indicates high-resistance earthing.

Check focusing of headlamp bulbs with lamp lenses removed, using a white screen with vertical and parallel intersecting lines to mark lamp centres.

If reflector surfaces are cloudy or scratched, new or replated reflectors are needed.

Rewiring with cable of insufficient cross-area will introduce voltage loss.

Faulty Dippers

If dipping reflectors stick, blow fuses repeatedly, or are sluggish, see that there is no distortion due to damage. Use light machine oil or cycle oil sparingly to lubricate pivots, plunger, tappet-rod contact with reflector plate, and striker-peg contact with lifting pad. Use 6-amp. fuse in 12-volt unit and 10-amp. fuse in 6-volt unit. See that contacts are separated not before two-thirds of full plunger stroke. Too early separation causes chatter and fuse trouble. Mounting screws must be tight and fuse secure in clips. Note that 6-volt units have yellow Empire-cloth covering of winding, and 12-volt units have black. Clean contact surfaces with nail file.

Repeating-type foot switches have ratchet-held three-legged rotor. If the dipper fails to operate every sixth stroke, condemn the switch.

Wiring P.L.C. Switch

When wiring a P.L.C. switch, connect ammeter wire to outside *A* terminal—not the ignition *A*—as this is internally bridged and is not intended to carry lighting load.

Bulbs

Do not allow greasy finger marks to remain on bulb globes as the heat causes them to vaporise and give off gases injurious to reflector surface.

It is very unwise to look at a lighted headlamp bulb with the naked eye: use smoked glass.

Filaments should be inspected for signs of sag and the glass for internal clouding, indicating imminent failure. A milky glass denotes incomplete air extraction due to faulty manufacture. A bulb with loose cap should be condemned, as vibration will cause early breakage of filament leads.

SERVICING TECALEMIT DL- AND DR-TYPE FUEL-FEED PUMPS

By C. H. B. PRICE

THE Tecalemit low-pressure fuel pumps, types DL and DR, are intended for use with petrol, benzol, and fuel oil, and have a low working pressure, giving at the same time, in the case of the standard model, a steady flow of 0-15 gallons per hour, determined by engine requirements.

Two standard models of pumps are available, the DL lever pump (Fig. 2), and the DR for push-rod operation. In each case a simple hand priming-lever is provided for use when initially filling the fuel system.

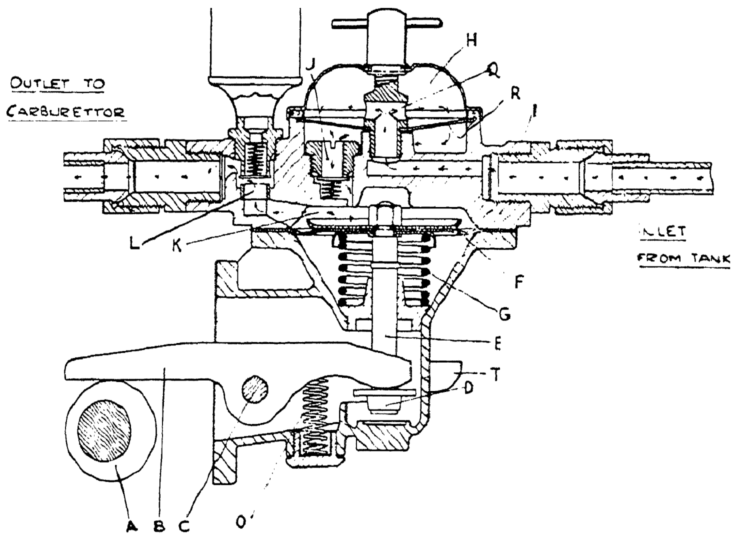


Fig. 1.—SECTIONAL DIAGRAM OF TECALEMIT FUEL PUMP (TYPE D)

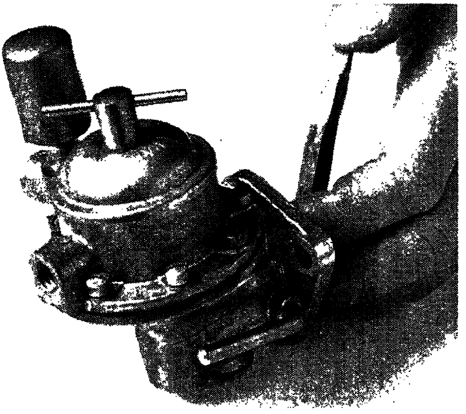


Fig. 2 (*left*).—GENERAL VIEW OF TECALEMIT "D"-TYPE FUEL-FEED PUMP

The priming lever at the right-hand side of the pump can be clearly seen, together with the drive lever and the filter cover.

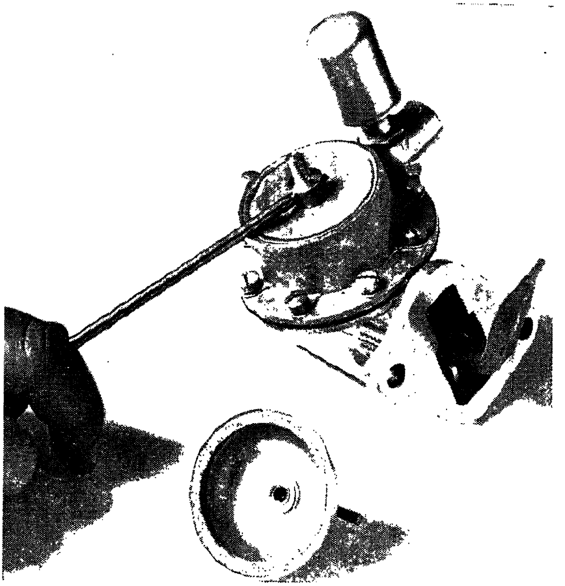


Fig. 3 (*right*).—DISMANTLING FUEL-FEED PUMP (1)

This shows the first operation in dismantling which follows removal of the filter cover assembly. A tommy bar is inserted in the centre pillar which is then unscrewed, when it will be found possible to lift the filter screen clear of the pump body.

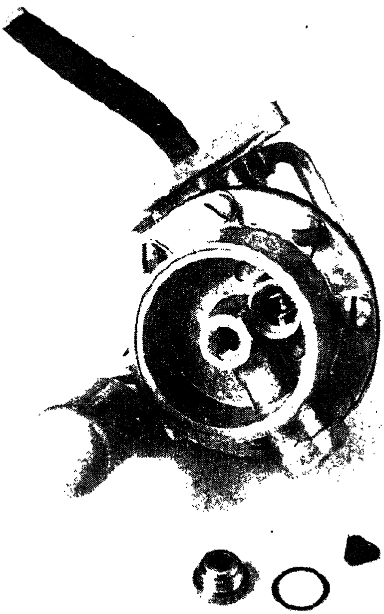
Description of Operation

The sectional diagram (Fig. 1) indicates how the eccentric *A* on

the engine camshaft causes lever B to oscillate about pivot C and depress collar D on spindle E, and pulls the diaphragm F downward against the action of spring G. This produces a vacuum on the upper face of the diaphragm, causing fuel to enter chamber H by means of union I and passage Q,

Fig. 5 (*below*).—DISMANTLING FUEL-FEED PUMP (3)

In this view, the inlet valve seat body has been removed together with the inlet valve and the fibre joint. At the bottom of the inlet valve pocket can be seen the inlet valve spring in position.



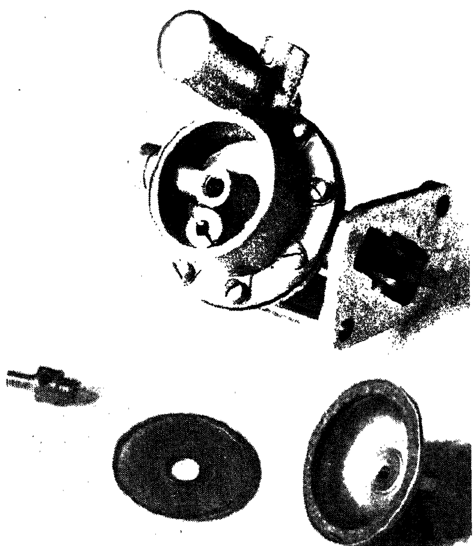


Fig. 4.—DISMANTLING FUEL-FEED PUMP (2)

Shows the centre pillar with filter screen removed from position. The inlet valve seat body can be clearly seen in position.

from where it passes down through the filter gauze R and inlet valve J to chamber K.

As the eccentric rotates, the lever B will tilt, assisted by spring O, allowing the collar D, spindle E, and diaphragm F to rise by virtue of spring G so as to pump fuel in chamber K past the outlet valve L to the carburettor or injector pump, as the case may be.

Should the engine demand the full quantity of fuel, the diaphragm follows the full stroke, but when (in the case of a carburettor) the float-chamber needle

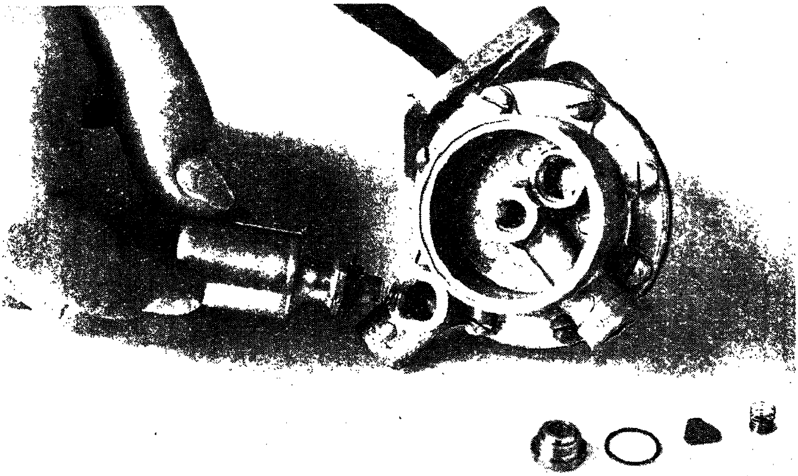


Fig. 6.—DISMANTLING FUEL-FEED PUMP (4)

This shows the removal of the air dome together with the outlet valve spring and fibre joint, leaving the outlet valve in position.

valve closes, a back pressure develops at the working face of the diaphragm, causing a lag in action between the collar *D* and the working face of the lever *B*.

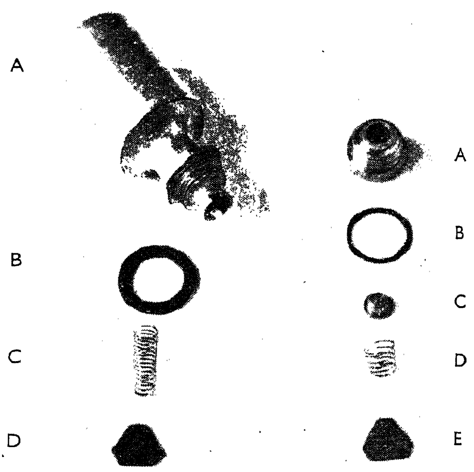


Fig. 7 (*left*).—DISMANTLING (5)

Reading from top left to bottom and top right to bottom, the following are shown:

A. Outlet Valve Air Dome.
B. Fibre Joint.
C. Outlet Valve Spring.
D. Outlet Valve.

A. Inlet Valve Seat.
B. Fibre Joint.
C. Spigot for Inlet Valve Spring.
D. Inlet Valve Spring.
E. Inlet Valve.

The difference between the lengths of the two valve springs is clearly shown in this illustration. They are not interchangeable. It will also be seen that the inlet and outlet valves are identical.

Device for assisting Easy Starting

A certain level of fuel will be maintained in air dome *P* while running, and the cushion of air trapped in the dome will permit a small quantity of fuel to flow to the float chamber when the engine is at rest, to make up for evaporation losses in the float chamber, thus assisting in an easy start.

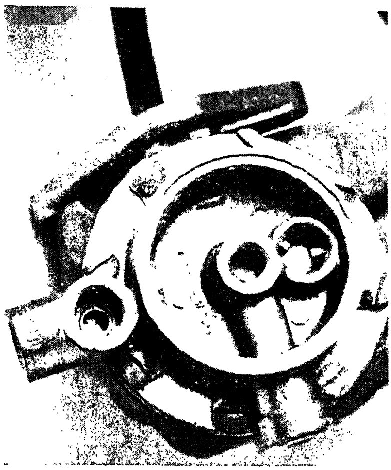


Fig. 8.—DISMANTLING THE FUEL PUMP (6)

View showing all valve gear removed from head casting. The outlet valve seat insert is clearly shown in this illustration.

Service Notes

When ordering spares or service units, always quote the number in full which will be found stamped on the pump flange.

Occasionally remove filter bowl and gently wipe away dirt on face of gauze. *Do not remove gauze* for this operation, as dirt might enter. Tighten bowl nut firmly after removal.

Three circumstances only are likely to make it necessary to examine the petrol-supply system; these, together with the remedies, are set out below.

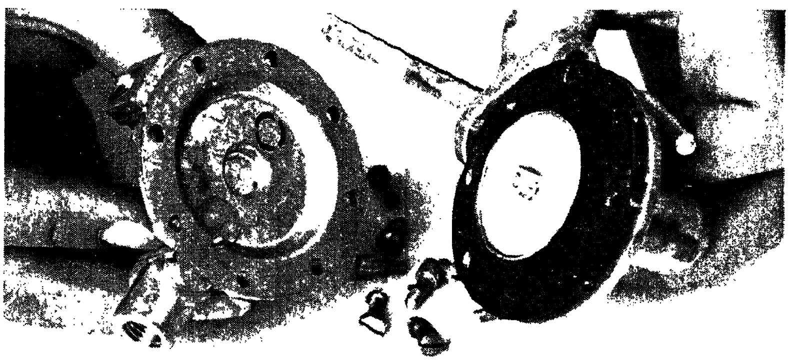


Fig. 9.—DISMANTLING THE FUEL PUMP (7)

View showing head casting removed from base casting. It should be noted that the upper face of the diaphragm is known as the working face.

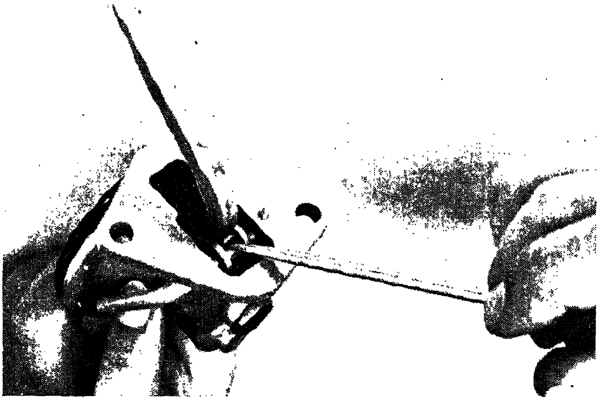


Fig. 10 (*left*).—DISMANTLING FUEL PUMP (8)

To complete the dismantling of the unit, the primer drive pin is removed in the manner shown.

FUEL-SUPPLY TESTS

Lack of Fuel in Carburettor Float Chamber

Possible Cause	*Remedy*
(1) Fuel tank exhausted	Replenish tank.
(2) Loose pipe unions .	Tighten all connections in petrol-supply system.
(3) Damaged piping .	Renew where necessary.
(4) Filter-cover nut loose	Remove bowl, examine cork joint, replace if in good condition, and tighten bowl nut.

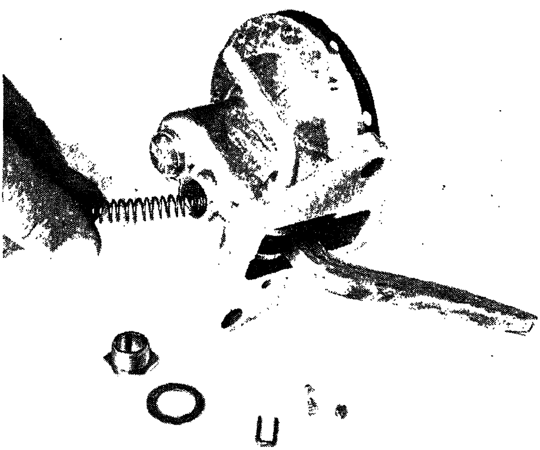


Fig. 11 (*left*).—OVERHAULING THE UNIT

Removal of lever spring showing ball and spring used in locating the priming lever. Also the primer drive pin.

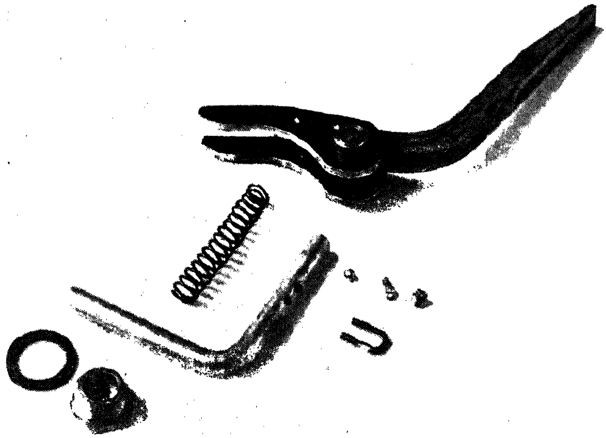


Fig. 12.—OVERHAULING THE PUMP
View showing the drive and priming lever assembly.

(5) Filter choked . .	Remove bowl, wipe gauze gently with clean rag. NOTE: *Centre bolt and gauze should not be removed for this operation.*

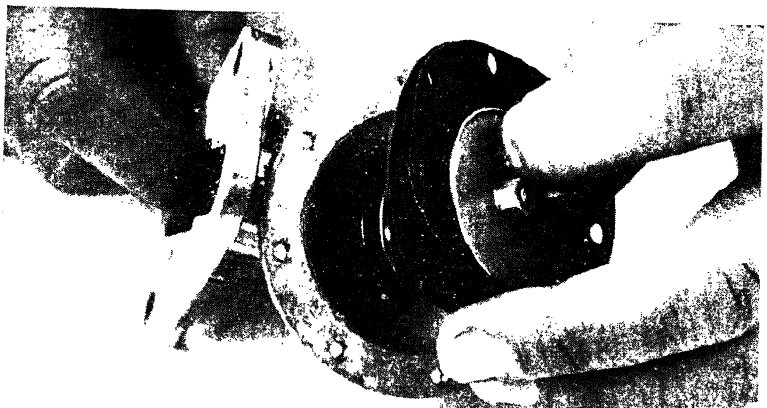


Fig. 13.—OVERHAULING PUMP
Showing the removal of diaphragm assembly complete which follows the removal of the drive lever. In this view the four laminæ can be clearly seen.

Fig. 14 (*left*).—VIEW SHOWING THE DIAPHRAGM ASSEMBLY COMPLETE

This assembly is complete in itself and should be changed as a whole when it becomes necessary to renew either the diaphragm or the diaphragm spring. The washer shown between the brass bushing and the spindle end of the washer is of a special fibre and takes the thrust from the drive lever.

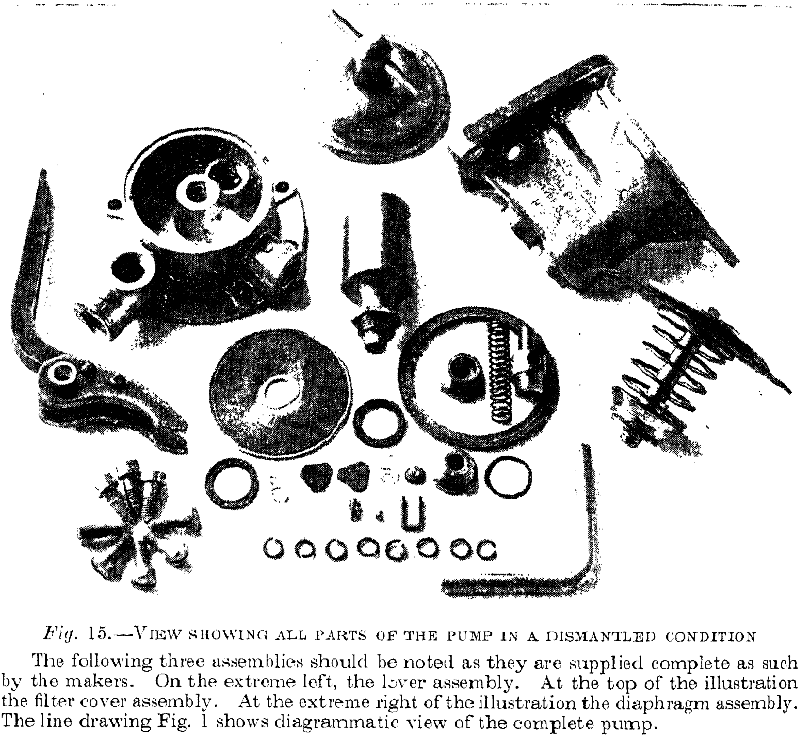


Fig. 15.—VIEW SHOWING ALL PARTS OF THE PUMP IN A DISMANTLED CONDITION

The following three assemblies should be noted as they are supplied complete as such by the makers. On the extreme left, the lever assembly. At the top of the illustration the filter cover assembly. At the extreme right of the illustration the diaphragm assembly. The line drawing Fig. 1 shows diagrammatic view of the complete pump.

Lack of Fuel in Carburettor Float Chamber—*continued*

Possible Cause	*Remedy*
(6) Leaking valve plug Outlet L (*see* Fig. 1) .	Tighten by spanner at hexagon beneath air dome P (*see* Fig. 1).
Leaking valve plug Inlet J (*see* Fig. 1) .	Remove centre pin by passing small tommy bar through fuel duct Q, unscrew and release gauze R (Fig. 1). Tighten plug by wide screwdriver in slot.
(7) Bent or damaged valves. (Remote unless tamperage is suspected.)	Remove valve plugs and valves. Carefully cleanse in petrol and examine valves and valve seats for defects. Tecalemit fuel-pump valves are interchangeable, and care should be taken to see that they seat flat and are not on edge when being replaced. The valve springs should be handled with care. These are not interchangeable, inlet with outlet.

Leakage of Fuel at Diaphragm Flange

Possible Cause	*Remedy*
Loose screws in flange. (In view of the flange design this possibility is remote.)	Tighten all screws equally and gently in rotation.

Flooding of Carburettor

Possible Cause	*Remedy*
Carburettor needle valve not seating.	Examine carburettor for adjustment. Clean float chamber and needle seat.

Note.—The primer lever T (*see* Fig. 1) is for use only when the engine is at a standstill, with empty fuel lines and carburettor.

The correct method of operation for priming is to push the lever down and release. This should be repeated until fuel is seen to be emerging from carburettor, when " tickler " is used to depress float. Normally a few turns of the engine should preclude the need for priming.

Procedure for Dismantling and Overhaul

The procedure for dismantling and overhauling is shown in Figs. 3 to 15.

THE APPLICATION OF A COMPRESSION GAUGE FOR ENGINE TESTING

By S. G. MUNDY, M.I.E.E., A.M.I.A.E., M.I.M.T.

A COMPRESSION gauge properly used is of great utility in diagnosing and locating the causes of loss of compression.

A good reliable gauge should be used, and connected by rubber hose in the sparking-plug position, using a suitable connector according to the size of the plug fitted.

Tests should be made by turning over the engine on the spark meter (using an auxiliary battery for this purpose, if necessary) with all plugs removed. The engine should be at normal operating temperature.

The purpose of a compression test is to determine what faults, if any, exist in the compression of individual cylinders, in order to indicate whether the power impulses are uniform. This is more important than the actual value of the compression readings.

How to make a Compression Test

(1) Remove all sparking plugs.

(2) Insert the proper adapter in No. 1 cylinder and connect the compression-gauge hose.

(3) Lock the throttle wide open, and see that the carburettor choke valve is also wide open.

(4) Crank the engine with the starter, and note the maximum reading obtained on the compression gauge.

(5) Having recorded the reading, remove the adapter, pour about 1 oz. of engine oil on top of the piston, taking care to see that this oil is kept clear of valves.

(6) Replace the adapter and repeat the compression test. The oil will temporarily seal the piston rings. If the compression does not materially rise, it indicates that the rings are tight and any loss in compression is past the valves. If, on the other hand, the compression rises by 10 lb. or more over the first reading without oil, it shows an excessive leakage past the rings.

How to make a Complete Analysis of Engine Condition with the Compression Gauge

By setting out the test figures in the form of a schedule, the condition of the engine can be completely analysed, as follows:

SCHEDULE SHOWING METHOD OF ANALYSING ENGINE CONDITION BY MAKING A COMPRESSION TEST

SCHEDULE No. 1

	A	B	C	D	E
Cylinder No.	*Dry*	*Oil-sealed*	*Bore Loss*	*Valve and Gasket Loss*	*Total Loss*
1	45	55	10	5	15
2	40	42	2	18	20
3	48	55	7	5	12
4	50	60	10	X	17
				$(28 \div 4 = 7)$	

(1) Insert the normal compression reading in column A.

(2) Insert reading with oil seal in column B. One cylinder (No. 4 in the example used) will give a maximum reading.

(3) The difference in the readings between columns B and A represents the loss past rings, and is entered in column C.

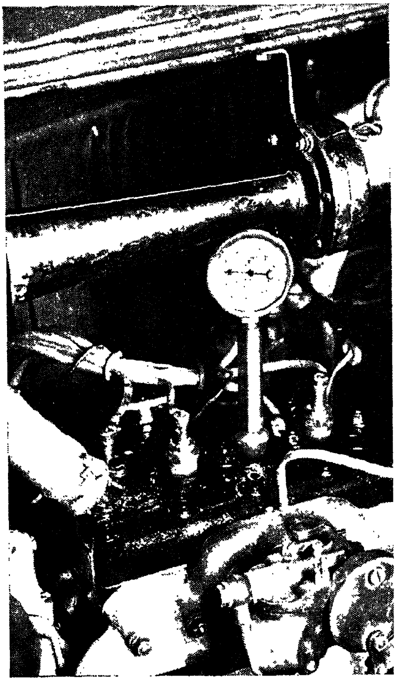
(4) The maximum reading in column B represents the most efficient cylinder, and all other cylinders should correspond. The difference between the maximum and lower readings represents a loss of compression past valves or gaskets, and is entered in column D for all cylinders except the cylinder which gave the highest reading on the oil seal. It must not, however, be taken for granted that this high-reading cylinder is perfectly sound, and an allowance factor must be determined to compensate for any loss past valves which may exist in this cylinder.

(5) This allowance factor is obtained by adding together the readings in column D and dividing by the total number of cylinders, thus giving an average loss to be allowed for the final cylinder X. In the example used, the total valve and gasket loss is 28, which is divided by the number of cylinder, namely $4 = 7$ lb. loss for No. 4 cylinder.

(6) We now add together columns C and D, which gives us the total loss of compression as in column E.

A frequent mistake when making compression tests is to base the analysis only on the results shown in column C, that is, the difference between the dry and oil-seal readings. Such an analysis, in the case of the example used, would probably result in the customer being told that cylinders Nos. 2 and 3 are good because they show a bore loss of 2 lb. and 7 lb. respectively, and that cylinders 1 and 4, although not so satisfactory as others, do not yet merit attention because they each show a bore loss of 10 lb.

If, however, a complete analysis is made, it shows that although the bore loss of No. 2 cylinder is very low, yet the valve loss is very high and calls for immediate attention. Since this means removing the cylinder head, attention can at the same time economically be given to cylinders



TESTING THE COMPRESSION

Showing use of compression tester with special rubber adapter inserted in sparking-plug hole. The gauge is held in position by hand.

1 and 4, which have a fairly high bore loss and might justify the fitting of oversize piston rings.

Analysis of the above Schedule

A "balance test" made with a vacuum gauge by short-circuiting cylinders in turn showed the cylinders to have the following descending order of efficiency: 3, 1, 4, 2; this complies closely with the compression-test results.

An analysis based only on the results shown in column C, where no thought has been given to fully determining the condition of the cylinders, or where it has been deemed "too much trouble," would have resulted in the customer probably being told that "Cylinders 2 and 3 are good, and cylinders 1 and 4—although less efficient—do not yet merit attention."

The complete analysis, as covered by the schedule, indicates clearly that whilst the bore of cylinder No. 2 is excellent, the valve loss is high and calls for immediate attention; and since this has to be done, attention could also be given at the same time to the bores of cylinders 1 and 4, where the fitting of oversize piston rings would in all probability rectify the loss of compression taking place.

The Use of a Compression Gauge for Fuel-pump Testing

This test is made by connecting the compression gauge through a screwed-in special tee-fixture between the petrol pump and the carburettor, and running the engine at a speed equivalent to about 10 m.p.h.

The pressure reading on this test will be about $2\frac{1}{2}$ to $3\frac{1}{2}$ lb. A fuel pump will work and give satisfactory results at a pressure of 2 lb. provided the carburettor has been properly adjusted. Pressures seldom exceed $3\frac{1}{2}$ lb.

Too low a fuel-pump pressure will cause a high-speed miss because of lack of fuel delivered to the carburettor. Too high a pressure will cause carburettor to float and result in high petrol consumption because too much mixture is being delivered to the carburettor.

OPERATION, CARE, AND MAINTENANCE OF KLAXON HORNS

THE electrically operated horns are vibrating-type units that operate on a magnetic principle to produce the warning signal. These horns are used as single units or in matched pairs with blended tone.

Current from the battery flows through the windings within the horn when the circuit is completed at the horn push-button switch. The magnetic attraction of the armature towards the pole causes a tension and slight movement of the diaphragm. This movement opens the contact points in series with the horn windings, breaking the circuit.

When the current is interrupted, the armature returns to its original position, relieving the tension of the diaphragm. The slight return movement of the armature and diaphragm allows the contact points to close, completing the circuit.

This cycle is repeated a great many times per second, resulting in a rapid vibration of the diaphragm. Each horn is designed to operate at a predetermined number of cycles per second to produce its characteristic warning signal. The pitch of the horns depends upon the number of vibrations per second, the high-note horns having the greater frequency.

Conditions Affecting Horn Performance

The following conditions affect the performance of the horns and should be checked before attempting to make any adjustments to the instruments :

Low Horn Voltage

If the horn produces a weak signal, the voltage at the horn should be noted.

Connect a voltmeter from the horn terminal to earth when checking horns having one terminal. Connect the voltmeter across the horn terminals when checking horns having two terminals.

The voltage readings should not be less than 5·25 volts (6-volt system) or 11 volts (12-volt system). A lower reading would indicate either a low battery or a high resistance in the horn circuit.

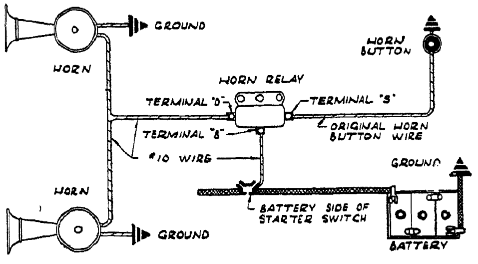


Fig. 1.--WIRING DIAGRAM FOR PAIR OF KLAXON HORNS WITH A HORN RELAY IN THE CIRCUIT

Low Battery

Check the battery with a voltmeter or hydrometer for condition of charge. If low, the battery should be recharged.

Loose or Corroded Connections in Horn Circuit

Clean and tighten connections wherever necessary. Check for defective wiring by connecting separate test leads from the horn to the battery.

A loose connection or poor contact at the horn push-button switch may cause the horn to operate intermittently. Shunt around the horn button to determine whether there is poor contact at the push-button switch.

If a horn relay is used in the circuit, remove the relay cover and see that the relay operates. The relay is connected in the battery circuit and is remotely controlled by the horn push-button switch.

The horn relay must be connected as shown in Fig. 1 to prevent damage to the unit.

Wire in Horn Circuit

The wire in the horn circuit should be of sufficient size to carry the current required to operate the horns. Use 0·064 in. diameter wire or larger for models 16, 26, and 31 Klaxons and 0·1 in. diameter or larger for model 33.

Mounting

Some horns are earthed internally and have but one terminal. In this case, a good earth connection to the frame of the car should be maintained through the mounting brackets. Horns must be fastened securely in position or the tone will be affected.

Loose or Damaged Parts

Horns usually have a rasping sound when vital parts are loose or broken. A loose backshell may affect the tone.

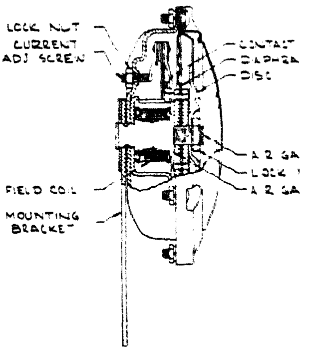
Tighten all collar screws, mounting nuts, and studs, and replace all damaged parts.

Some matched pairs of Delco-Remy Model 33 horns use a long and a short projector. The long projector must be used with the power unit stamped "L," and the short projector with the power unit stamped "S," or the horns will not perform properly.

Open, Shorted, or Earthed Circuits in the Horn

The horn will not function properly if the field windings are open-circuited, short-circuited, or earthed.

Connect an ammeter in the horn circuit at the horn terminal. If there is no indication of current flowing when the contact points are closed, the windings are open-circuited. The ammeter will indicate an excessive flow of current if the windings are short-circuited or earthed.



2.—KLAXON HORN (MODEL 16)

The windings in horns having two terminals may also be checked for earthed circuit by the use of test points and a test lamp.

Disconnect the horn leads and touch one test point to one of the horn terminals and the other point to the horn base. If the lamp lights, the field windings are earthed. This test does not apply to horns having one terminal, as these horns are earthed internally through the base.

Arcing or High Resistance at Contact Points

Excessive arcing at the contact points may be caused by improper current adjustment. An open circuit in the condenser (on Model 26 horns) or in the resistance unit (on Model 33 horns) will cause excessive arcing at the points, and in some cases the contacts will be held together. The horn will not function properly if the condenser or resistance unit is open-circuited.

High resistance at the contact points of Model 33 horns may be caused by an oxidised coating which sometimes forms on the contact surfaces. Usually a few light strokes with a thin contact-point file will dress the points so that the horns will produce the proper tone.

Adjustments

No adjustments should be necessary on new horns. However, if the tone is not satisfactory after checking the above conditions, it will be necessary to adjust the horns.

When adjusting matched pairs, one horn should be disconnected and attention confined to one instrument.

Klaxon Models 16 and 31

Current-consumption and air-gap specifications for these models are as follows: *Current consumption*: High-note 6-volt horns, 5–7·5 amps.; low-note 6-volt horns, 5–7·5 amps.; high and low-note 12-volt

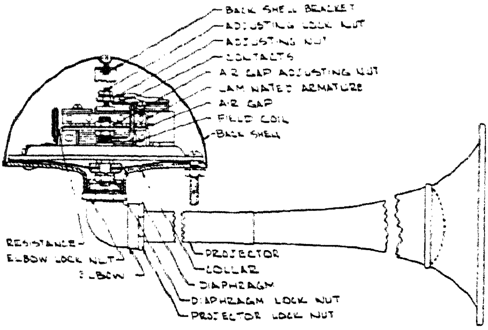


Fig. 3.—KLAXON HORN (MODEL 33-B)

horns, 3–4·5 amps. *Air Gap*: High-note 6- and 12-volt horns, ·015–·017 in.; low-note 6- and 12-volt horns, ·020–·022 in.

Connect ammeter in circuit at the horn and adjust current consumption by varying position of adjusting screw. Loosen the locknut, and turn current-adjusting screw to the left to increase the current, to the right to decrease the current. Increasing the current increases the volume. Too much current will cause the horn to have a sputtering sound. This adjustment is very sensitive. Move adjusting screw one-tenth turn and lock in position each time before trying the horn. If ammeter is not available, adjust according to sound.

If the tone of the horn is unsatisfactory after adjusting the current, remove the faceplate or projector and adjust the air gap.

Loosen the locknut and turn air-gap adjusting stud to the right until it touches the core. The horn will not sound when stud is in this position.

Back stud away from the core by turning three-quarters of one turn to the left, and lock in position. If the horn has a coarse, high pitch, turn air-gap adjusting stud to the left, and if the pitch is too low, turn stud to the right. Move stud one-tenth turn and lock in position each time when adjusting near the correct setting.

After each horn in a matched pair has been adjusted and operated individually as instructed, connect the units together and sound for blended tone.

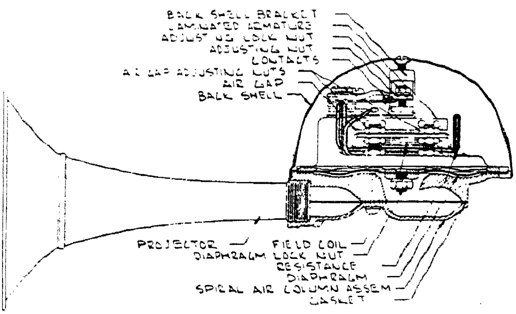


Fig. 4.—KLAXON HORN (MODEL 33-C)

Adjusting Klaxon Models 26 and 33

Adjust the current consumption, as already described for Models 16 and 31.

The correct air gap between the armature and core is very important for proper tone. The gap must be uniform across the entire

surface of the armature. The width of the gap may be determined by using a feeler gauge. Adjustments are made by means of the air-gap adjusting nuts.

After each horn in a matched pair has been adjusted and operated individually as instructed, connect the units together and sound for blended tone.

The Model 26 single 6-volt horns having the short projectors should be adjusted according to high-note specifications, and those with long projectors should be adjusted according to low-note specifications.

The following table gives the current-consumption and air-gap specifications.

Horn Model Number	*Current Consumption* High-note 6-volt Horns at 6 volts (Amps.)	Low-note 6-volt Horns at 6 volts (Amps.)	High- and Low-note 12-volt Horns at 12 volts (Amps.)	*Air Gap* High-note 6- and 12-volt Horns (in.)	Low-note 6- and 12-volt Horns (in.)
26-A, B, C, and D	5–6·5	6·5–8·5	3·5–4·5	·017–·020	·025–·029
26-E, F, and G	5–6·5	6·5–8·5	3·5–4·5	·019–·023	·025–·029
26-L	—	6·5–8·5	3·5–4·5	—	·025–·029
26-M, and S	5–6·5	6·5–8·5	3·5–4·5	·019–·023	·025–·029
33	11–13	11–13	8–11	·040–·047	·050–·057
33-B	11–13	12–14	8–11	·036–·040	·045–·050
33-C	10–12	11–13	8–11	·032–·036	·042–·046
33-D	11–13	12–14	8–11	·036–·040	·045–·050
33-F	9–11	11–13	8–11	·032–·036	·040–·044
33-S	10–12	11–13	8–11	·032–·036	·042–·046

CHECKING SMITH THERMOSTATS

With Notes on the use of Anti-Freeze

By F. J. GROSE

THE modern thermostat comprises a valve operated by a metallic bellows filled with a volatile liquid and set at a predetermined temperature. The movement of the bellows closes off the by-pass when the valve is full open. Thermostats are calibrated to start opening usually between 70° and 73° C.—suitable liquids being employed having boiling points to suit the desired temperature setting—and are full open at about 85° C. Pressure has no effect on the thermostat, as the area of the valve is equal to the mean diameter of the bellows and, therefore, balanced. Valves larger than the bellows will blow open under pressure and the temperature will be lower than that for which the thermostat is designed. The running temperature will be higher if the valve is smaller than the bellows.

Under normal conditions of control the thermostat valve is rarely more than $\frac{1}{16}$ in. off its seating, sufficient water passing through this area to give the desired control, as is proved by the fact that under running conditions the temperature of the engine is very close to the temperature at which the valve moves off its seating, namely 70°–73° C.

When a thermometer is used, it should obviously record temperature on the engine side of the thermostat.

The bellows is under vacuum, thus in the event of puncture (a very rare trouble) the valve will fly to the full-open position, eliminating any possibility of boiling.

Checking Thermostat when Temperature is lower than 70°–73° C.

First check thermometer readings—if one is fitted on the car (use an ordinary glass thermometer for checking, preferably at 60°, 70°, 80°, 90°, 100° C.). If the thermometer is satisfactory, remove the thermostat and place in water at 70°–73° C., moving the thermostat about during the test. The valve should be a few thousandths of an inch off its seating at 73° C., and should have a minimum of $\frac{5}{16}$ in. lift at 85° C. If the valve is permanently off its seating, it indicates that the bellows is punctured and must be returned for servicing. No repairs can be effected on a thermostat by a garage, as the thermostat is a sealed unit.

A thermostat is an accurate instrument calibrated to within $1\frac{1}{2}$° C., and is therefore entitled to at least occasional attention. It usually

gets the blame for all cooling-system troubles, but is in fact a very reliable fitting. All Smith thermostats are balanced and are unaffected by pressure—therefore low running temperatures cannot be attributed to the thermostat. There are, however, thermostats on the market with oversized valves which would definitely be the cause of low running temperatures.

Running Temperature too low—no Thermometer fitted on Car

The simplest way of testing a thermostat when no thermometer is fitted on the car is to insert an ordinary thermometer in the header tank when the engine is really warmed up. If the engine is running stationary, it should be allowed to rev. for at least ten minutes. The temperature in the header tank is usually about 2°–3° lower than the cylinder block; therefore, if the recorded temperature in the header tank is, say, 67°–68° C., it may safely be assumed that the thermostat is correctly set and controlling temperature in the cylinder block at 70°–73° C.

Car does not warm up Rapidly

Fill up with cold water and allow the engine to run at a fairly fast tickover. Under these conditions the thermometer should reach the normal setting of 70°–73° C. in 3–6 minutes approximately. (On the road under driving conditions this is more rapid.) During the period of warming up no hot water should pass into the radiator until the valve opens. The only water which can pass over is via the very small air-vent hole in the thermostat valve. If the radiator warms up approximately at the same rate as the cylinder block, then this indicates that the thermostat is faulty, and it will probably be found that the valve is permanently off its seating, due to a punctured bellows.

Engine Boils

Adopt the same procedure as when the temperature is lower than 70°–73° C. If the thermostat is found to be satisfactory, boiling must be due to some other cause, such as insufficient water in the cooling system, choked radiator (very often the case on an old car), pump requiring attention, or a kink in the rubber hose. In cold weather, freezing at the base of the radiator results in boiling, and very often the thermostat is blamed for this, but naturally has nothing to do with it.

Engine Temperature, although not boiling, is running very High

Adopt the same procedure for testing the thermostat as when the engine boils. If the thermostat is found satisfactory in regard to setting, the cause must be looked for elsewhere.

Note.—Various methods are adopted for closing the by-pass—the sliding-shutter method being shown in Figs. 1 and 2. A more positive

shut-off principle is shown in Figs. 2 and 3. All three are perfectly satisfactory, as it is not always necessary to use a design which will give positive close-off at the by-pass. Generally speaking, the more efficient the cooling system the less necessary it becomes to completely shut off the by-pass when the valve is in the full-open position.

THERMO-SYPHON-TYPE THERMOSTATS

This type of thermostat operates on a similar principle to the pump type, with the exception that it is set lower, usually at 65° C., and in order not to interfere with the free flow of water a butterfly valve is used. This type of thermostat will also fly to the full-open position in the unlikely event of the bellows being punctured. Thermo-syphon-type models are illustrated in Figs. 4 and 5.

It should be noted that all thermo-syphon-cooled systems can run as high as 97° C. under hot-weather conditions. It will therefore be obvious that the object of the thermostat for such cooling systems can only be to ensure rapid warming up from cold and prevent the engine temperature from dropping below the temperature at which the valve is set to start opening. It cannot prevent the temperature of the engine from running up as high as 97° C. Incidentally, boiling rarely results on a thermo-syphon cooled engine, even if the running temperature is as high as 97° C. Many owners are under the impression that a thermostat on a thermo-syphon cooled engine should prevent the engine from running at this high temperature, but it will be clear that this cannot be so.

Precaution when refilling Cooling System

When refilling the cooling system after it has been emptied, do so slowly, to ensure that the air is allowed to escape through the air vent in the thermostat. Rapid filling of the cooling system frequently results in an airlock and a partially filled cooling system, which will quickly boil and is likely to have serious results. If an engine boils and the car is driven, all the water will boil away, and it is possible for the temperature to be so high in the block that it will melt the solder on the thermostat.

Such thermostats should be returned to the manufacturer for examination with full particulars of the trouble. Excessively high temperatures —high enough to melt solder—are caused by loss of water as the result of boiling. The thermostat may cause the initial boiling due to incorrect thermostat fitting on the engine.

Bearing in mind that the liquids used in a thermostat, for pump-cooled engines, have known boiling-points, it is, therefore, impossible for a thermostat designed so that the valve starts to open at 70°–73° C. to give running temperatures on the road of, say, 95° C. It is usual to blame the thermostat, but this is absolutely wrong. To obtain a running temperature of 95° C. a liquid totally different from that employed for a setting of 70°–73° C. would have to be used.

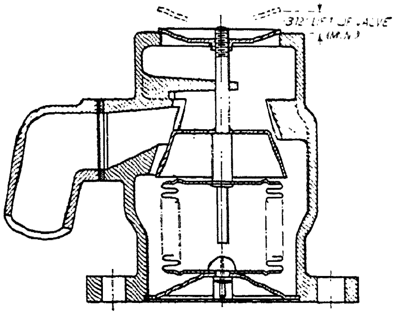


Fig. 1.—Conical shutter-type thermostat

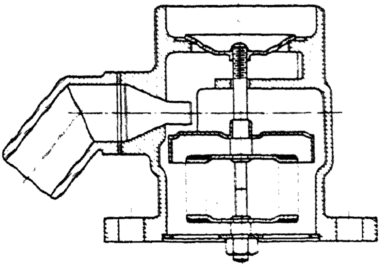


Fig. 2.—Conical shutter-type thermostat

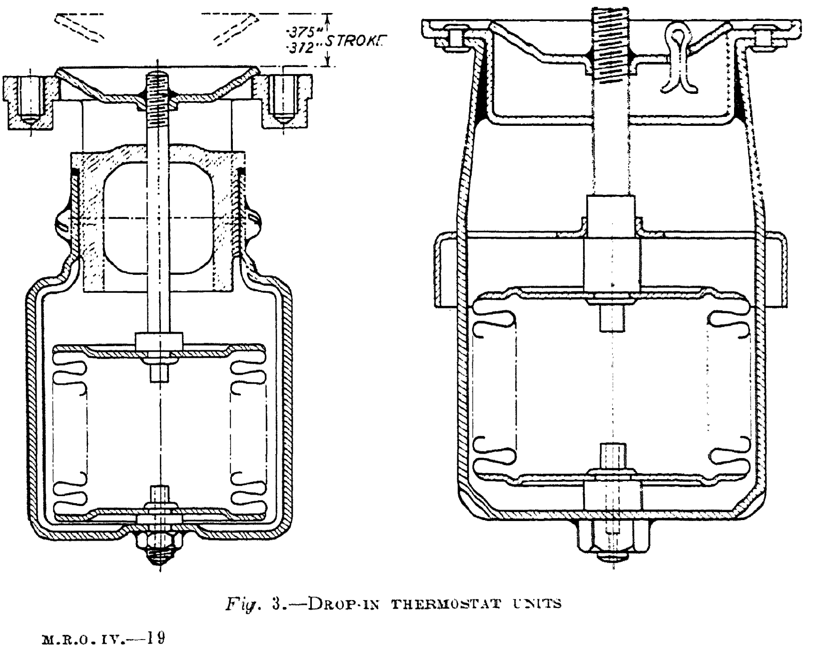


Fig. 3.—Drop-in thermostat units

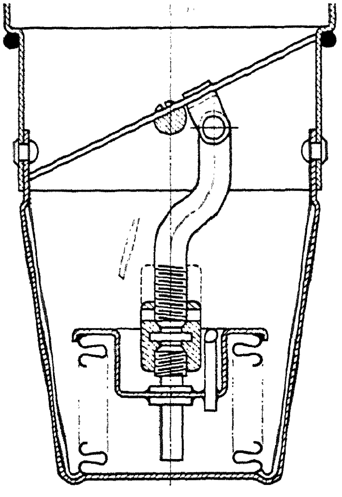


Fig. 4 (*above*).—BUTTERFLY VALVE THERMO-SYPHON-TYPE THERMOSTAT

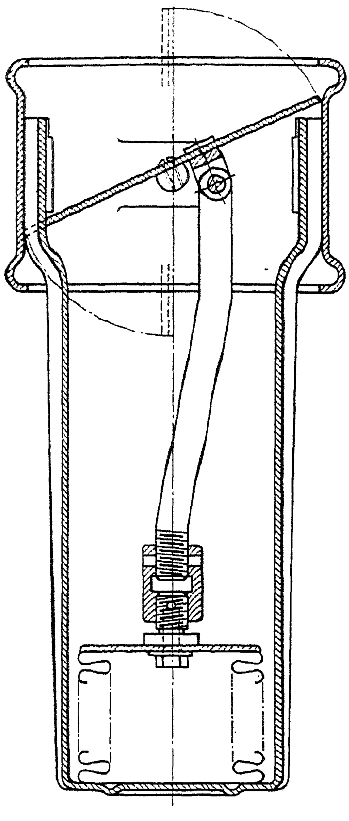


Fig. 5 (*right*).—THERMO-SYPHON HOSE-FITTING THERMOSTAT UNIT

Sticking rarely occurs in a thermostat, although it is customary for garages to assume that a thermostat has jammed if trouble occurs. It is easily proved when testing the thermostat by observing whether the valve moves freely in its guide. Thermostats must be moved rapidly in the water during the calibration test, otherwise it is not possible to check the setting accurately, as the sensitiveness of a thermostat is obtained by the flow of water over the metallic bellows.

USE OF ANTI-FREEZE

It is important to bear in mind, when a thermostat is fitted, that no water circulates through the radiator until the valve opens; therefore there is a greater tendency for the base of the radiator to freeze. A suitable anti-freeze should be used during the winter, and this should be added early in the season, and not left until frost appears.

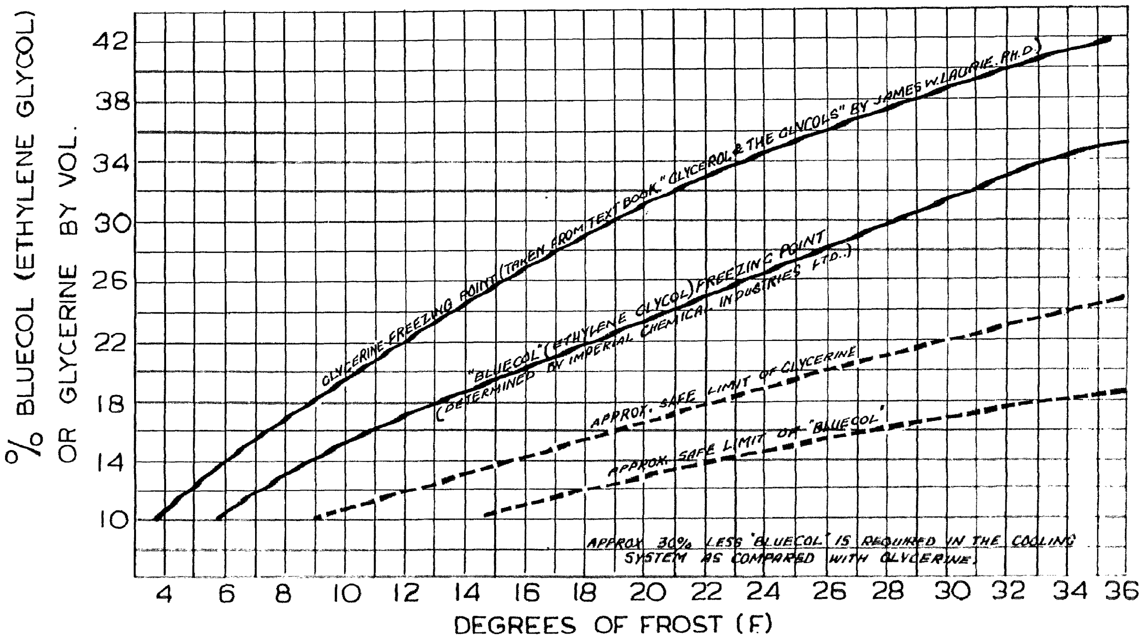


Fig. 6.—FREEZING-POINTS OF ETHYLENE GLYCOL INHIBITED (BLUECOL) AND GOOD GLYCERINE

Note. The freezing points given in the graph represent the temperature at which small crystals start to form. The solution turns to mush, which becomes thicker as the temperature decreases to the safe limit.

Engines with or without a thermostat are not safe from freezing, as many radiators have been known to freeze up on the road even after the engine has been well warmed up. Heated garages or lamps under the engine are also insufficient.

Anti-freeze prevents freezing up, provided sufficient is added to the cooling water. Lack of knowledge of this subject frequently results in trouble. Even a good anti-freeze can freeze up if insufficient is used.

Some anti-freeze mixtures on the market give very poor frost protection, making it necessary to add a large quantity to obtain effective protection. It is advisable, therefore, to make sure that the anti-freeze used will give the desired frost protection.

Full information covering the freezing-points of any recognised anti-freeze is published in chemical textbooks and is therefore available to all.

Amount of Anti-Freeze Required

The accompanying chart is given as a guide, and shows the frost protection which can be obtained by the use of Ethylene Glycol Inhibited, according to the quantity added.

Ethylene Glycol Inhibited (Bluecol) is a recognised non-corrosive anti-freeze, and gives the maximum frost protection of any anti-freeze on an equal-quantity basis.

ETHYLENE GLYCOL SOLUTION FREEZING-POINTS

By Volume	*Formation of Minute Crystals (Freezing-point)*	*Slightly Mushy*	*Hard Mush (Maximum Safe Limit)*
Percentage	*Deg. of Frost Fahr.*	*Deg. of Frost Fahr.*	*Deg. of Frost Fahr*
10	5¾	10	14
15	10	16	25
20	15¾	23	39
25		32	55
30		39	71

	Flows freely, safe for driving	Incapable of flowing, but unlikely to crack radiator or cylinder block. →

The graph given in Fig. 6 shows the freezing-points of Ethylene Glycol Inhibited (Bluecol) and good glycerine according to the percentage by volume.

Because of its high boiling-point and low viscosity, Ethylene Glycol is frequently used as a coolant instead of water on sports cars and on air-

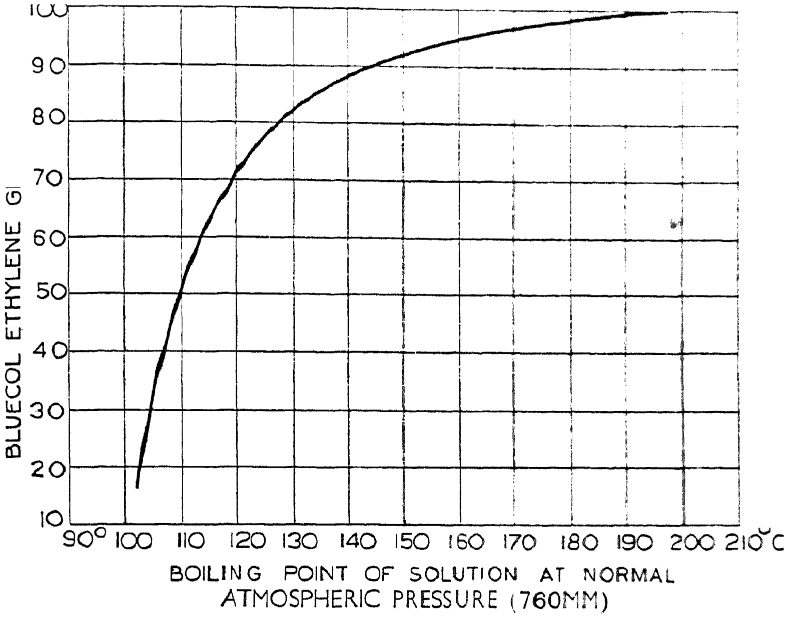


Fig. 7.—BOILING-POINTS OF ETHYLENE GLYCOL ACCORDING TO PERCENTAGE BY VOLUME

This information is useful when ethylene glycol is used as a coolant in the cooling-water system.

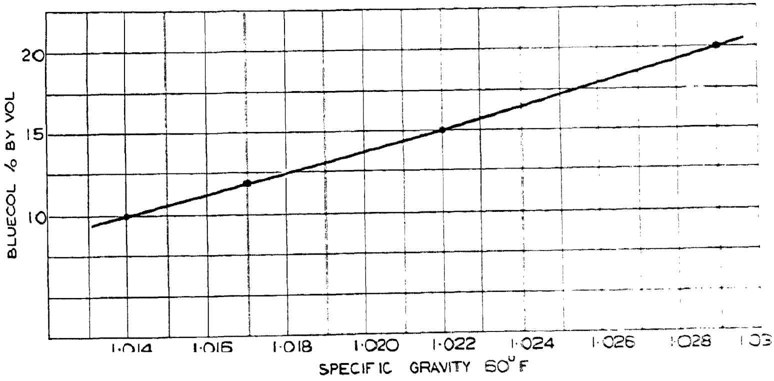


Fig. 8.—THE SPECIFIC GRAVITY OF ETHYLENE GLYCOL

craft engines. The boiling-points according to percentage by volume are given in Fig. 7.

Flush out Radiator before adding Anti-Freeze

All anti-freeze products have a tendency to loosen foreign matter in the radiator, and therefore it becomes essential to thoroughly flush out the cooling system before adding the anti-freeze, bearing in mind that, in the case of an old car, where there is in all probability a considerable amount of foreign matter in the cylinder block, the loosening of this foreign matter may choke the radiator. Efficient cleansing of the radiator becomes necessary, using any well-known product offered for this purpose.

It is customary to blame the anti-freeze if the radiator becomes choked—this is not the fault of the anti-freeze, but the fault of the owner in not ensuring that his cooling system is properly cleansed. Once the cooling system is clean, a good anti-freeze will keep it clean.

Alcohol anti-freeze is inflammable and easily evaporates at normal running temperatures—it should be avoided.

An anti-freeze must not attack the solder or metals used in the cooling system or thermostat. Ethylene Glycol, containing the correct anti-corrosive inhibitor, is known to be satisfactory.

THERMOMETERS

The modern thermometer comprises a Bordon tube and a rack and pinion. Solid-filled thermometers are sometimes employed, but the usual type operates with vapour pressure. The sensitive end of the capillary tube is provided with a union nut, so that the bulb may be screwed into a convenient part of the engine or radiator when provision is made for screwed fixing. Alternatively, an expanding rubber connector is available, permitting the fixing of a thermometer bulb in a rubber hose provided it is of canvas ply, or in a hole drilled in a metal water-pipe.

On some thermostats a screwed connection is provided for thermometer fixing, but if this is not so, the thermometer should always be fitted between the thermostat and the cylinder block, in order to obtain cylinder-block temperature. Radiator header-tank fixing should be employed only when no thermostat is provided.

LUBRICATION AND LUBRICATING OILS

By E. A. EVANS, M.I.A.E.

Chief Chemist to Messrs. C. C. Wakefield & Co., Ltd.

WHEN oil is allowed to flow between one plate and another which is tilted, a wedge of oil is produced. Whatever length that wedge may be, the pressure along its whole length is the same. If the two plates are pulled apart or pushed together without altering their angular positions, and the flow of oil is maintained, the pressure throughout the film will still remain constant. At the narrowest part of the wedge the flow of oil is restricted, but this does not affect the pressure within the film or the rate of flow, because the excess oil simply leaks out at the sides. Imagine now that the pressure of the oil feed is increased. Although a greater volume of oil is passing into the wedge, the pressure within the wedge remains the same, as the extra volume escapes from the sides. When the side leakage is restricted in some way, the pressure within the wedge simply builds up along its entire length.

Lubrication of Shaft and Bearing

Between a bearing and the shaft there is always a gap, which is called "the clearance." The shaft is free to assume any position which circumstances dictate. When at rest it will lie on the bottom of the bearing, leaving the greater clearance at the top, and when it rotates it will lift off the bearing and possibly move sideways. The running position is dependent upon the applied load and speed and, to a lesser extent, upon the viscosity of the lubricant. The eccentricity of the shaft within the bearing creates a wedge-shaped gap through which the lubricant will flow. The oil pressure within the gap is all-important to efficient lubrication, and nothing should be done to impair the building up of sufficient pressure in the narrowest part of the wedge. A loss of pressure at this point of nearest approach may result in complete rupture of the oil film, followed by metal-to-

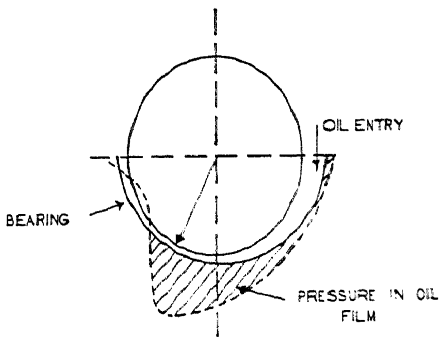


Fig. 1.—LUBRICATION OF SHAFT AND BEARING

metal contact, and finally melting of the bearing metal. The oil may be force-fed to the bearing by a pump, where the flow is assisted by the pushing action of the rotating shaft on the oil.

Oil Pressure

The dimensions of the clearance affect the rate of flow, the volume of oil passing, and the pressure gradient. Using a constant-volume pump, the same volume of oil will flow through the clearance whatever its dimensions may be. The only variable will be the pressure. In a big clearance the pressure will be less than when the clearance is small. A high oil pressure at the point of nearest approach is essential to support an intensive load which may be constantly or intermittently applied. The engineer aims at balancing the load by the oil pressures acting on the surface of the journal. In practice a release valve is inserted between the pump and the bearing, so that the pressure can be adjusted at will.

The Discovery of Film Lubrication

The modern conception of lubrication is based upon experiments made by Beauchamp Tower in 1883, and the immediate years following. These experiments were made for the Institution of Mechanical Engineers. In anticipation of fitting a lubricator, he drilled a ½-in. hole into a brass bearing, and found that oil poured out of it when his machine was set running. To prevent it, a wooden plug was driven into the hole, but on restarting the plug was forced out. He then fitted a pressure gauge, and discovered that the pressure in the film was sometimes as great as twice the mean pressure calculated by dividing the total load by the projected area of the bearing.

Osborne Reynolds published his classical paper in 1886, in which he interpreted Tower's experiments in his famous theory based on hydrodynamics. He developed a differential equation for the pressure distribution in the converging film. The lubricant adheres to both the moving and the stationary surfaces and, by virtue of its viscosity, develops a positive fluid pressure in the converging film. No such pressure can be developed between parallel surfaces. The discovery of the converging film has made possible important developments in lubrication.

Michell, inspired by Reynolds, invented his famous thrust bearing. The fundamental principle incorporated is a series of pivoted pads or shoes so arranged that they produce a converging film of oil. The pressure within the film will carry enormous loads. It is particularly applied in the larger hydro-electric and marine installations.

What is the " most suitable Lubricant " ?

Film lubrication need not be a chance affair. Sufficient is known to enable engineers to calculate the correct size and geometry of a bearing for a particular job. However accurately a bearing is made, it cannot

function perfectly without the most suitable lubricant. The expression "most suitable lubricant" is not meant to imply that there is only one best lubricant for any one specific purpose. It is meant to emphasise that as much care should be given to the selection of the lubricant as to the design of the bearing. The term "suitable" is chosen deliberately to differentiate between suitability and quality. A quality oil is one which is well refined. The most suitable oil for a specific purpose, however, may not be a quality oil, but one chosen for some special characteristic, which may be low coefficient of friction, high viscosity index, or perhaps high film-rupture strength.

Changing from Thin to Thick Oil

So far, consideration has been given only to one type of fluid. A thin oil will flow through the clearance more rapidly than a thick oil. To maintain the pressure, therefore, more of the thin oil must be pumped. On the other hand, when a thick oil is used, less must be pumped. Consequently, if a car engine is set for a thin oil and it is decided to change to a thick oil, it may be necessary to readjust the pressure relief valve.

"Thick" and "Thin" Oils and their Effects

The terms "thick" and "thin" are relative, and not definite. The scientist has therefore introduced methods to determine these characteristics in absolute units, which he describes as viscosity. Viscosity may be described as the resistance of a fluid to flow or to a shearing stress. In a bearing, the oil film is subjected to a shearing stress by the journal rubbing against it. When the viscosity of the oil is low the film is easily deformed and the fluid friction is low. Conversely, when the viscosity is high the fluid friction is high. As friction is usually manifested in heat production, it follows that any unnecessary fluid friction results in higher bearing temperature. This single fact emphasises the advisability of using as low a viscosity oil as is consistent with running conditions. A closely fitted bearing with small end leakage can operate successfully with a low-viscosity oil, provided the film pressure is maintained by an adequate supply of oil. An added advantage to thin-oil lubrication is that the bearing is kept cooler, by virtue of low fluid friction and by the rapid dissipation of heat conducted to the bearing by the large volume of oil passing through it. Further, the life of a bearing metal is greatly extended if it is kept at a low temperature. There is considerable evidence that white-metal bearings suffer rapidly from fatigue under high temperature conditions, crack, and ultimately disintegrate. A thick oil may be employed when the rubbing speed is low, and when the feed is reduced.

How Viscosity of an Oil is Measured

Viscosity is commonly measured by noting the time for a given volume of oil to flow through a narrow tube. In the petroleum industry the

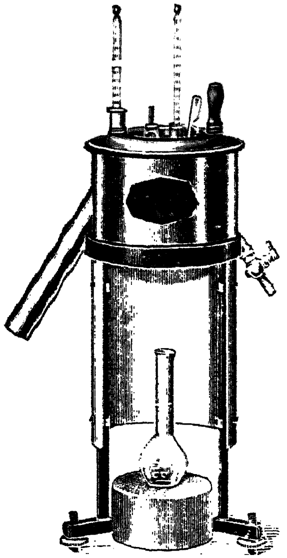


Fig. 2.—REDWOOD VISCOMETER FOR MEASURING THE VISCOSITY OF OILS

viscometer consists of a metal container, similar in shape to a cylindrical tin box, with a short length of capillary tube fixed in at the base. The oil in the container has its temperature adjusted by a surrounding bath, filled with water or oil which can be heated or cooled at will. After the temperature of the oil has been adjusted, a given volume is allowed to flow through the capillary into a glass graduated flask, and the efflux time is noted.

In Great Britain and the U.S.A., where the Redwood and the Saybolt viscometers are used respectively, the viscosity is stated in the number of seconds required for the outflow of 50 c.c.

The Germans favour the Engler modification, and express the result as a multiple of the viscosity of water.

These methods of expression are purely arbitrary and have no scientific basis. The best that can be said for them is that relative terms as "thin and "thick" can be classified numerically. For purposes of scientific lubrication a mathematical expression is essential, and is available. Sometimes the results are given in centipoises, but the more up-to-date unit is the centistoke. Such absolute units are measured in scientifically designed viscometers.

How Viscosity changes with Temperature

Viscosity being a property subject to temperature variations, it is essential to record the temperature at which the viscosity is measured. Very approximately the viscosity of an oil falls 2 per cent. per degree Fahrenheit rise. If, instead of giving the percentage change, the viscosity is plotted against temperature, on graph paper, curves can be drawn which will give a pictorial representation of the change of viscosity with temperature. Oils with a large change will have a steep curve, and those with a small change will have a flatter curve. Hence people speak of oils with a steep or a flat viscosity curve. Again a difficulty arises—how steep or how flat? The problem is at the moment surmounted by resorting to numerical values. As Pennsylvanian oils have flat curves, they have been given a value of 100, and the steep-curve oils, such as the Coastal, a value of 0. By a graphical method, comparisons with these two classes are possible and the result is given as viscosity index.

It would be improper to suggest what the viscosity index of a good oil

should be, in view of price considerations and other factors. Suffice it to say that popular proprietary grades of motor oils vary from 85 to 105 according to their viscosities.

Why Lower-viscosity Oils are gaining in Favour

Through improved forced-feed lubrication combined with better engineering practice, lower-viscosity oils are gaining in favour, not merely as a fashion but as a scientific possibility. Reference has already been made to the reduced fluid friction in thin oils, and to lower bearing temperatures. It must now be apparent that as high-viscosity index oils are in use, a considerable sacrifice of viscosity at atmospheric temperature is permissible without loss of viscosity at the working temperature of the engine. A few examples will make this clear.

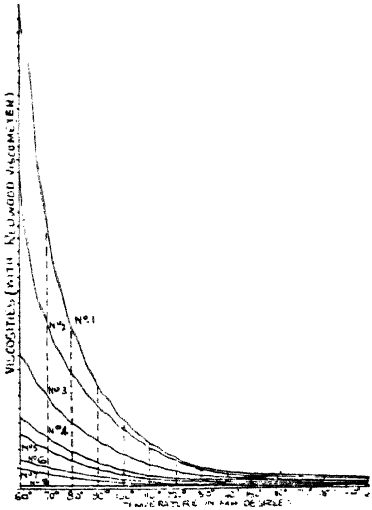


Fig. 3.—VISCOSITY AND TEMPERATURE CURVES FOR MINERAL OILS

This shows the change in viscosity with temperature for a number of different oils.

Viscosity Index	*Viscosity at 70° F.*	*F.*
	1,500 seconds, Redwood 370 centistokes	69 seconds, Redwo 15 centistokes
	2,600 seconds, Redwood 640 centistokes	69 seconds, Redwo 15 centistokes
102	750 seconds, Redwood 185 centistokes	53 s 10 c
	1,300 seconds, Redwood 320 centistokes	53 s 10 c

Lubrication at the Moment of starting the Engine

At the moment of starting a petrol engine, the moving parts rely upon the residual oil on them for their lubrication. Before they secure an efficient film, oil must be pumped and delivered. The speed of delivery is controlled by the viscosity of the oil at the temperature of starting. At

a very low temperature the oil may be so viscous as to be unpumpable. At a higher temperature pumping becomes possible, but its projection to the pistons takes several minutes, and finally a temperature is reached to permit rapid circulation. Temperature and viscosity are so linked that they must be considered together. With descending temperature the oil always increases in viscosity, and ultimately becomes like a non-fluid petroleum jelly. It is essential, therefore, that there shall be set a maximum viscosity at the lowest starting temperature, in addition to the minimum viscosity at the working temperature.

The user need not in general worry about these facts, because they are agreed between the engine builder and lubricant producer. An oil in the temperate zones must nowadays be satisfactory down to 10° F., and even lower. For arctic temperatures specially low cold test oils are necessary.

The Oiliness of a Lubricant

Oiliness of a lubricant is an essential qualification about which little is accurately known. Many attempts have been made to measure it, without much success. This need not eliminate its consideration. In film lubrication, however, fluid friction is the main factor, simply because the metal surfaces are too far apart to be influential. That is not so when the surfaces are an infinitesimal distance apart, when film lubrication has given place to boundary lubrication. Boundary lubrication depends upon the ability of the lubricant to adhere to the metal surface. An insufficient adherence renders a fluid a non-lubricant. To explain why some fluids possess adherence and others do not involves scientific explanations which are outside the sphere of this article. Suffice it to say that every substance is composed of very minute particles called molecules, some of which are attracted by the molecules of another substance, in much the same way as iron filings are drawn to a magnet, and held there until a force greater than the magnetic force is applied to push them off. Thus the adsorbed layer of a lubricant has a film-rupture strength equal to the attractive force between the oil molecules and the metal molecules. Any force greater than this breaks the film and allows the two opposing metal faces to come into contact. The oil molecules arrange themselves in a very definite way on the metal surface. Petroleum molecules stand vertically, and simply bend over when a rubbing force is applied, like the bristles in a brush. Fatty acids, on the other hand, orient themselves at an angle of about 64°, and incline to an angle of about 5° when a rubbing force is applied. Furthermore, the fatty acid molecules form small units of five molecules, arranged with one molecule at each corner of a rectangle and one in the middle. This specific grouping draws an important distinction between petroleum or hydrocarbon lubricants and fatty oils which are compounds of fatty acids and glycerine. The static friction, or friction at the moment of starting, is of the order of 0·3 when using hydrocarbons, and about 0·1 with fatty oils or acids, except in the case of

castor oil which is about 0·03. The low co-efficient of friction of fatty oils renders them exceptionally useful in boundary lubrication. The peculiar property of the orientation of fatty oil molecules is emphasised by the fact that as little as 1 per cent. of fatty oil in a petroleum oil will give a static friction equal to that of the fatty oil, due to the selective adsorption of the fatty oil by the metal surface. Under running conditions such a small amount of a polar body may be inadequate to provide the necessary oiliness.

Extreme-pressure Oils

Until recent years any force greater than that which would rupture an oil film could only be met by introducing into the oil graphite, mica, or some other solid lubricant. Solid lubricants, however, present difficulties in application, mainly owing to their tendency to separate from an oil. Naturally, the finer the solid particles are, the longer will they remain in suspension. To obtain, therefore, the best suspension, the particles should be exceedingly small and the oil as viscous as is conveniently possible. The introduction of the hypoid gear into rear axles has focused increased attention on film-rupture strength. Although the hypoid gear is not extensively used in British cars, it is used freely in American cars; hence it is incumbent upon students of lubrication to familiarise themselves with this innovation. The characteristic of a hypoid gear is the high tooth pressure together with considerable rubbing or sliding. This combination of forces strains the lubricating film even to destruction, depicting the result in a pitted or scuffed metal surface. To overcome the rupture of the oil film, certain compounds of sulphur, chlorine, or phosphorus can be added to the oil. Such compounds do not in themselves act as lubricants, but produce on the metal surface a particular form of oxide which is quickly transformed into a very hard and very thin layer or coating which is known to scientists as a Beilby layer. This layer carries the burden very efficiently. Hypoids have developed, and the loads intensified, with the result that the mild extreme-pressure lubricant has become insufficient for the latest development. The still more active lubricant is known as the hypoid lubricant. Research is now revealing that if a better finish is produced on the rubbing surface the hypoid lubricant is not so essential. The drift, therefore, seems to be backwards towards the mild extreme-pressure oil. The application of this principle to engine oils is complicated by the high temperature of the piston. It is too early to record successes. Suffice it to say that much encouraging research has been done, and mild extreme-pressure engine oils can be produced.

Carbon on the Piston Crowns

An oil in its travels in an internal-combustion engine encounters heat, hot air, exhaust gases, and metal surfaces. Individually and collectively they decompose the oil. The oil is pumped from the engine sump through

the crankshaft to the bearings, and then shot out with sufficient velocity to atomise it and project it to the cylinder walls, where it is picked up by the pistons and transported to the hot zone at the top of the piston travel, where it is exposed to the flame of the burning fuel.

There is a belief that the incandescent gases burn the oil, and leave a solid residue of carbon on the piston crown. Certainly the deposit is black and has the appearance of coke, but appearances may be proved by scientific methods to be misleading. Chemical analysis has proved that combustion-space carbon contains up to 21 per cent. of combined oxygen. This revelation is of great importance, because it reveals the fact that the so-called "carbon" is neither carbon nor coke, but highly oxidised hydrocarbons. If it were coke it would be almost 100 per cent. of elemental carbon. Carbon being insoluble in organic solvents such as petrol, benzene, and chloroform, has misled people into believing that if the combustion-space deposit is intimately mixed with benzene or chloroform to extract anything which is soluble, the remaining insoluble portion is carbon.

Chemical analysis of this insoluble matter has shown that it may contain up to 35 per cent. of combined oxygen, so it is material which is even more oxidised than the soluble portion. How much free carbon is present in the deposit is exceedingly difficult to estimate. In Diesel engines occasionally the total carbon, which must include combined and free, is unusually high. This strongly suggests that free carbon is present. The presence of free carbon would be expected when black smoke is being emitted from the exhaust. Generally the composition of Diesel-engine deposits is similar to that of petrol engines.

Methods of improving Lubricating Oils

The petroleum industry has spent vast sums of money on research to improve lubricating oils. The three principal lines of attack have been refining, alteration, e.g. hydrogenation, and use of inhibitors. During the last few years the revolution in methods of refining has vastly improved the oils in a variety of ways. The demand for longer intervals between oil drainings and decarbonising has led to the production of oils which are more immune to oxidation. Refining removes the constituents of petroleum which are readily susceptible to oxidation, but over-refining robs the oil of valuable ingredients. A line of demarcation between refining and over-refining is consequently necessary. The position of this line is sometimes exceedingly difficult to locate, owing to the balance of requirements. Suppose that an engine is designed, either inadvertently or purposely, to rely on boundary lubrication, a full quota of oiliness compounds must be left in the oil; alternatively, if it be constructed for complete film lubrication, a little over-refining is permitted to limit oxidation. A compromise is sometimes obtained by adding oxidation inhibitors. Very little success has been obtained with those organic inhibitors which retard

the combination of hydrocarbons with atmospheric oxygen. Greater success appears to have been reached by the addition of metallic soaps to the oil to eliminate the auxiliary oxidising influence of the iron surfaces. Iron and copper, either in the metallic state or as organo-metallic compounds, have a pronounced deleterious action on all lubricating oils: hence anything which can be done to check their activity will result in greater longevity of the oil and cleanliness of the engine. Chromium and tin plating are being studied with the same object in view.

Ring Sticking and Sludge

Ring sticking and sludge in the crankcase are other manifestations of oil oxidation. Ring sticking is frequently attributed to an excessively high temperature. It has been found, however, that if the fault cannot be cured by a change of oil, or a reduction in temperature, considerable relief can be attained by the use of tapered rings. Such a change necessitates a change of piston to accommodate the special rings. This change may not be convenient, so it is pleasant to remember that chemical compounds, called detergents, can be added to the oil to keep the deposit from forming in the ring grooves. Some care is necessary in selecting these compounds, because they do not all behave amicably with copper-lead or cadmium-alloy bearings.

SYSTEMATIC FAULT DIAGNOSIS

By S. G. MUNDY, M.I.E.E., A.M.I.A.E., M.I.M.T.

WHEN a car owner visits a garage and complains of missing, sluggish engine, poor acceleration, hard starting, etc., the correct policy is immediately to check over the car, using the proper equipment and following the correct system, so that the owner can be shown the causes of his trouble—in other words, the alteration which has taken place from original standards of adjustment, and what replacements or repairs are necessary to restore the standards and therefore restore performance.

The same policy can, wherever possible, be followed when a car owner asks for his plugs to be cleaned or carburettor to be adjusted. It should be recognised that the reason the car owner asks for this service to be carried out is because he has noticed a falling-off in the performance of his car. Had a loss of performance not been noticed, it is improbable that he would have asked for the adjustments to be made.

The owner may feel that all he needs is to have the carburettor adjusted or plugs cleaned ; what he really needs and expects is " to have the performance of his car restored."

With modern equipment it is an easy matter to check over any car in a systematic way in order to determine the service needed to restore performance.

It might be thought that such a complete examination would take too long to be practical. This, however, is not the case, because, provided the correct instruments are available and the proper system of testing is followed, it is possible to make a complete examination of any car in from thirty to sixty minutes, according to the type of car and the number of cylinders.

The Essential Equipment

The essential equipment required to do this is :

(1) A vacuum gauge, for checking engine mechanical condition and cylinder balance ; for verifying condition of ignition and carburation, and for checking and resetting ignition timing and carburettor adjustment.

(2) A voltmeter, for checking the ignition system, contact-breaker points, and for making electrical tests, etc.

(3) An ammeter, for checking battery consumption, ignition-coil consumption, and for making electrical tests.

(4) A sparkmeter, for checking ignition high-tension system, and testing and adjusting sparking plugs, etc.

Testing and Tuning Chart

Illustrated is a complete chart which outlines an easy and proved method of checking over any car in a systematic way. This chart shows the sequence of the various tests, gives diagrams of the connections, indicates the readings for normal performance, and also gives indications of any trouble as shown by incorrect readings.

Test should be carried out in the same sequence as given in the chart, and as follows :

1. Battery and Starter

Make connections as indicated. With ignition ON, operate the starter and note the reading on the voltmeter. If the voltage is less than 9/10 volts with 12-volt system, or 4½/5 volts with 6-volt system, it indicates a defective battery, starter cables, or earthed connections.

Test 1 (*a*).—At the same time as the above test is made, the ammeter (600-amp. range) can be connected in series with the starter to battery cable, or if a "Tong Test" ammeter is available, it can be clipped around the starter-to-battery cable and a check of the current consumption made.

The consumption should be compared with the standard figures for the type of starter and, if excessive, the starter should be examined.

If topping-up or recharging or reconditioning is required, advise customer.

2. Engine Mechanical Condition

This test verifies the mechanical condition of the engine. It is made by connecting a vacuum gauge to the induction manifold. Drill and tap the manifold 3BA, using a drill smeared with grease, inserting the attachment in the vacuum-gauge hose, and screwing this into the tapped hole in the induction manifold.

With the throttle completely closed and with the lead to the coil "SW" terminal still disconnected, as in the preceding test, carefully note the vacuum reading. This should be approximately as follows :

With a single carburettor—15 in., with slight even pulsation.

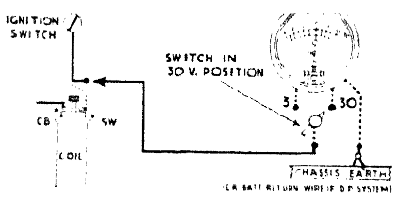
With a twin carburettor—12 in., with slight even pulsation.

With a triple carburettor—10 in., with slight even pulsation.

If the reading fluctuates in excess of about 1 in. or is irregular, it indicates valve trouble. A low and unsteady reading also indicates valve trouble. If the reading is low and steady it suggests air leaks in the induction system. The carburettor should be checked. If the reading is unduly high, a compression test should be made, as it suggests possibility of bad bores.

TESTING AND TUNING CHART

1. BATTERY AND STARTER



A. Disconnect lead from "SW" terminal of ignition coil and reconnect it to one lead of voltmeter.

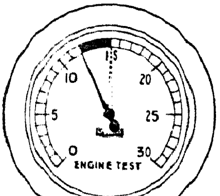
B. Clip tong-test ammeter round "starter to battery" heavy cable.

C. With ignition ON, operate starter. Note voltage reading on voltmeter. Note current reading on ammeter.

If VOLTS Read—	*INDICATES—*
LESS than 9/10 VOLTS (12-volt system) LESS than 4½/5 volts (6-volt system)	Defective battery, starter cables, or earth connection.

If AMPS Read—	*INSPECT—*
ABOVE NORMAL	Starter, starter switch, and starter cables.

2. ENGINE (with engine warm)



A. Connect vacuum gauge to intake manifold.

B. *Completely* close throttle.

C. With lead to coil "SW" terminal still disconnected, press starter and note reading.

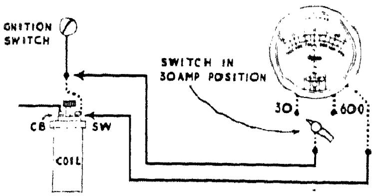
Correct Reading: Steady or only slight and regular pulsations, at following levels—

SINGLE Carburettor	15 in.
TWIN Carburettor	12 in.
TRIPLE Carburettor	10 in.

If READING—	*INDICATES—*
FLUCTUATES in excess of normal pulsation	Valve trouble.
LOW AND UNSTEADY	Valve trouble.
LOW AND STEADY	Air leaks in induction; check carburettor.
UNDULY HIGH	Check for bad bores and re-boring (confirm by compression test).

Testing and Tuning Chart *continued*

3. IGNITION



A. Connect one ammeter lead to disconnected wire from coil "SW" terminal.

B. Connect other ammeter lead to the coil "SW" terminal.

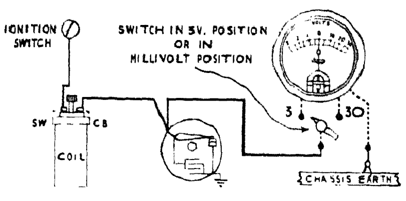
C. Close the contact-breaker points, and, with engine stationary, note the ammeter reading.

Correct Readings:

12-volt system.	6-volt system.
$2\frac{1}{2}$ amps., with variation not more than $2\frac{1}{4}$ to $2\frac{3}{4}$ amps.	4 amps., with variation not more than $3\frac{1}{2}$ to $4\frac{1}{2}$ amps.

If READING is—	*INDICATES—*
HIGH	Defective ignition coil or short-circuits.
LOW	Defective contact-breaker points, poor connections, broken wire, or bad earth.

4. DISTRIBUTOR



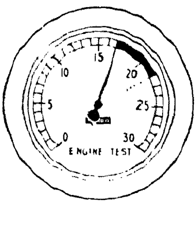
A. Reconnect ignition switch lead to coil "SW" terminal.

B. Connect one ammeter lead to contact breaker and the other lead to earth.

C. See that contact-breaker points are still closed and voltmeter switch set in 3-volt position or 150 millivolt position if voltmeter has millivolt scale.

If VOLTS Read—	*INDICATES—*
NOT GREATER than 0·05 volts (50 millivolts	. Contact points efficient.
OVER 0·05 volts (50 millivolts) . .	. Contact points need cleaning.
OVER 0·075 to 0·1 (75 to 100 millivolts)	. Check distributor for loose connections, contact-breaker points for adjustment or replacement.

5. CARBURETTOR



A. With vacuum gauge connected to intake manifold (as in Operation No. 2), run engine at idling speed and note reading.

B. Adjust carburettor slow-running jet for highest steady vacuum reading. Give "burst" of speed and note effect.

If vacuum becomes more *steady*, try adjusting carburettor at slightly higher idling speed.

Testing and Tuning Chart—*continued*

6. BALANCED RUNNING

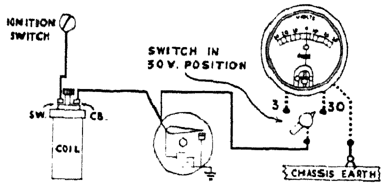
A. With vacuum gauge connected as in previous operation, short-circuit each cylinder in turn with screwdriver and note drop in vacuum reading as each cylinder is cut out.

Six- or Eight-cylinder Engines : When testing six- or eight-cylinder engines, two or more plugs can be earthed in turn to throw engine temporarily out of balance for clearer indication of vacuum drop per cylinder.

If VACUUM GAUGE Reads—	*INDICATES—*
ANY ONE cylinder giving smaller drop than others .	Check for trouble
TWO OR MORE cylinders giving small drop .	Usually valve trouble.

Note.—When only one cylinder gives *small drop*—check for poor rings. (Compression test can be used to diagnose cylinder condition.)

7. ELECTRICAL

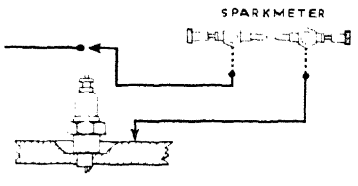


A. Connect one voltmeter lead to ignition coil " CB " terminal and other to earth.

B. Run engine at fast idling speed and note voltmeter reading.

If VOLTS Read—	*INDICATES—*
HIGH	Wide contact-breaker points, charging rate too high, loose, dirty, or corroded charging-circuit connections.
UNSTEADY	Mechanical distributor fault.
LOW . .	Contact points too close or poor connections in ignition low-tension circuit.

8. HIGH TENSION



A. Disconnect each plug lead in turn.

B. Connect one sparkmeter lead to the end of the plug lead and the other sparkmeter lead to earth.

C. Set the sparkmeter gap at 7-8 mm. and note if the sparking at the gap is regular.

INDICATIONS

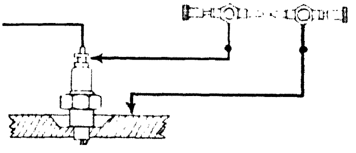
Important.—Sparking should be uniform.

If MISSING—	*INDICATES—*
On ALL Leads	Defective ignition coil, condenser, contact breaker, or distributor rotor.
On ISOLATED Leads	Defective distributor cap or defective plug lead.

Note.—In all cases involving the use of the sparkmeter, the lead connected to the " live " side (non-adjustable point of gap) should be connected to the " feed " side of the high-tension circuit (nearest the coil).

Testing and Tuning Chart—*continued*

9. SPARKING PLUGS



A. Connect one sparkmeter lead to each plug terminal in turn and the other sparkmeter lead to earth.

B. (i) Adjust sparkmeter gap to 4 mm.
(ii) Adjust gap to 1–1½ mm.

INDICATIONS

METER GAP set at 4 mm.	NO SPARK.
METER GAP set at 1–1½ mm. . . .	REGULAR SPARKING.

Note.—There should be regular flashing at neon tube in both cases. All plugs uniform.

If PLUGS—	*INDICATES*—
Do not comply with these conditions .	Plugs should be cleaned and adjusted or replaced with new plugs of correct type.

In some cases regular sparking is difficult to obtain at 1–1½ mm. In such cases accelerate the engine, and if regular sparking is obtained during the accelerating period the condition of the plugs can in most cases be accepted as satisfactory.

10. FINAL TUNING

A. Make final adjustments to carburettor as in Operation No. 5 until highest steady-vacuum reading is obtained.
Richen carburettor until you see the vacuum needle just about to drop; this is the point for maximum power and acceleration.

B. Slacken distributor head and advance or retard ignition until highest steady reading on vacuum gauge is obtained.

C. Then retard ignition until the vacuum gauge drops approximately down to ½ in.

THIS COMPLETES THE TUNING SERVICE, AND THE CAR CAN NOW BE HANDED OVER WITH REPORT OF ANY FURTHER SERVICE REQUIRED

3. Ignition Test

This is a test of coil consumption which will indicate the general condition of the ignition system. Connections should be made as indicated. Close the contact-breaker points and, with the engine stationary, note the ammeter reading. With a 12-volt system it should be within 2¼ to 2¾ amps. With a 6-volt system it should be within 3½ to 4½ amps.

If the reading is high, it indicates a defective ignition coil or short-circuits. If the reading is low, it indicates defective contact-breaker points, poor connections, a broken wire, or bad earth.

4. Distributor (Contact Points)

Make connections as indicated. With the contact-breaker points closed and the voltmeter switch in the 150-milli-volt position, note the reading. If this is not greater than 50/75 milli-volts, the contact points can be passed as efficient. If the reading is over 50/75 milli-volts, the points require cleaning. If over 75 to 100 milli-volts, the distributor should be checked for loose connections and for cleaning and adjustment or probable replacement of the contact-breaker points.

5. Carburettor

With the vacuum gauge connected to the induction manifold, as in Check No. 2, run the engine at idling speed and note the reading. Adjust carburettor slow-running jet for the highest steady-vacuum reading which can be obtained. Give a " burst " of speed and note the effect. If the vacuum becomes more steady, try adjusting the carburettor at a slightly higher idling speed.

This is only a preliminary adjustment. Final adjustment is made in Check No. 10.

6. Cylinder Balance

With the vacuum gauge still connected as in Check No. 5, short-circuit each plug in turn with an insulated screwdriver. Note the drop in the vacuum reading as each cylinder is cut out. When testing six- or eight-cylinder engines, two or more plugs can be earthed in turn to throw the engine temporarily out of balance, which will give a clearer indication of vacuum drop per cylinder.

If the engine is properly balanced, the vacuum drop should be uniform for each cylinder. If any one or more cylinders give a smaller drop than others, a further examination should be made for trouble. Details will be found in the section "How to make a Complete Analysis."

7. Electrical Check

Make voltmeter connection, as indicated, with voltmeter at 30-volt range. Run engine at fast idling speed. The voltmeter reading should be approximately half the battery voltage, and steady.

If the voltmeter reading is high, it indicates wide contact-breaker points, charging rate too high, or loose, dirty, or corroded charging-circuit connections.

If the reading is unsteady, it indicates a mechanical distributor fault. If the reading is low, it indicates contact points too close, or poor connections in the ignition low-tension circuit.

8. High Tension

Disconnect each plug lead in turn and connect one sparkmeter lead to the end of the plug lead and the other sparkmeter lead to earth. With

the sparkmeter gap at 7 to 8 mm., sparking should be regular and uniform for all leads. If missing takes place on all leads, it indicates defective ignition coil, condenser, contact-breaker points, or distributor rotor. If missing takes place on isolated leads, it indicates defective distributor cap or plug lead.

Note.—Whenever the sparkmeter is used, the lead connected to the live side (non-adjustable point of the gap) should be connected to the "feed" side of the high-tension circuit (nearest the coil).

9. Sparking Plugs

Connect one sparkmeter lead to each plug terminal in turn and the other sparkmeter lead to earth.

With the sparkmeter gap adjusted at 4 mm. there should be regular flashing in the neon tube, but no sparking at the sparkmeter.

Now reduce the gap to 1 to 1½ mm., when there should be regular flashing at the neon tube and regular sparking at the sparkmeter gap. If the plugs do not comply with these conditions, they should be removed and cleaned and adjusted, and, if this does not overcome the difficulty, replaced.

Note.—If regular sparking is difficult to obtain at 1 to 1½ mm., accelerate the engine; if regular sparking is then obtained, the condition of the plugs can, in most cases, be accepted as satisfactory.

10. Final Tuning Adjustment

First make final adjustment to the carburettor, as in Check No. 5, until the highest steady-vacuum reading is obtained. Richen the carburettor until the vacuum needle is just about to drop; this is the point for maximum power and acceleration. Slacken the distributor head and advance or retard the ignition until the highest steady reading on the vacuum gauge is obtained. Then retard the ignition until the vacuum gauge drops approximately down to ½ in.

The service includes both these adjustments.

This completes the "tuning service," and the car can now be handed over to the car owner—with a report of any additional service recommended.

STARTER DRIVES

DESIGN, OPERATION, AND SERVICE INFORMATION

By E. T. LAWSON HELME

THE drive or coupling between the starter and the engine must achieve the purpose of initial engagement, with a degree of elasticity in order to absorb the sudden stress when the rotating armature shaft becomes meshed with the stationary flywheel, and automatically to disengage the drive when the engine starts and overruns the starter.

The "Bendix" Drive

The "Bendix" drive, developed from early designs, comprises a sleeve with a "quick" square thread on which the pinion rides, the latter being threaded internally to correspond to the sleeve thread, like a nut on a bolt. The sleeve fits over the armature shaft but is not secured to it. A driving dog is keyed to the shaft, and the flat steel coil-spring links the dog to the sleeve by studs screwed into each, round which spring ends are looped. The dog stud has an extension entering a hole in the shaft to act as a locating peg, while the sleeve stud has no extension, and clears the shaft. The inward side of the driving dog is formed with a flat on each side, while a corresponding collar is located in a groove on the sleeve, these being engaged like a dog clutch, the other end of the sleeve being closed by a riveted-on ring. The inward side of the pinion has a ring

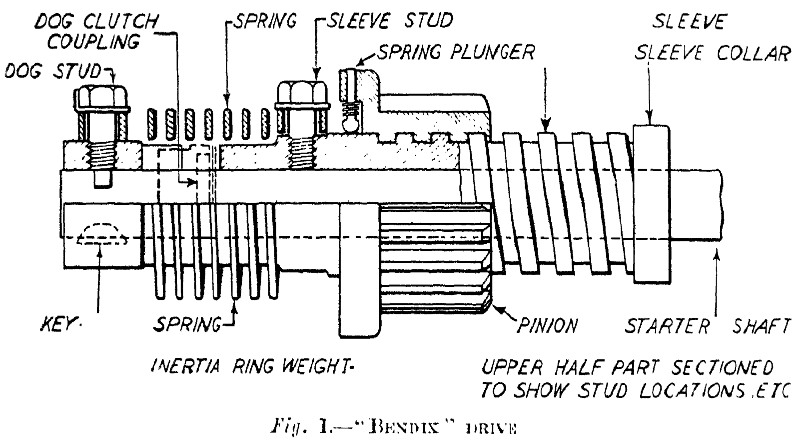


Fig. 1.—"BENDIX" DRIVE

riveted on, one side being machined, so that the peripheral weight is unequal. A small spring-loaded pin projects through a hole in the ring and bears on the sleeve. Fig. 1 shows an outline of the construction.

Operation of "Bendix" Drive

When the starter accelerates from rest, the unbalanced inertia of the weighted pinion causes it to lag behind in speed, so that the sleeve, in effect, screws out of the pinion, and the latter advances, meets, and meshes with the flywheel teeth, screwing hard against the sleeve collar. The pinion and sleeve meet the resistance to rotation of the flywheel and, the drive being transmitted from shaft dog to sleeve through the spring, the latter tends to wind up, providing resilient coupling. The dog clutch allows the sleeve to slide on the shaft to a limited extent.

When the engine starts, flywheel resistance to the drive is removed, and the engine overrun causes the pinion to rotate faster than the sleeve and starter shaft. The pinion immediately screws back and retreats out of mesh, disconnecting the drive.

When the engine is running and the starter at rest, the pinion is restrained from travelling along the screw by the pressure of the spring plunger peg, which wedges the pinion on the screw tightly enough to prevent "creeping" but allowing inertia action to urge the pinion forward on starter acceleration; the unbalanced ring-weight "unwedging" the thread. The principle is the same for both outboard and inboard designs.

Lucas Compression Drive

The same purposes are achieved in a different manner in the Lucas compression drive, the spring in this case cushioning the drive by compression instead of by torsion. Fig. 2 shows an inboard drive of this type. The shaft is splined, and the screwed sleeve internally cut to a sliding fit on the shaft, the splines ensuring positive rotational coupling. There is no riveted-on collar, the inward end of the sleeve being open. The pinion moves spirally on the screwed sleeve, but has no inertia ring-weight or spring plunger. A heavy coil-spring is fitted between outward end of sleeve and shaft nut. The shaft drive-end bearing journal is in the form of a flanged barrel pressed on the shaft, and a hard steel thrust-ring is interposed between the open end of the sleeve and the outer edge of the journal. When the shaft nut is screwed home and cotter-pinned to the shaft, the spring is slightly compressed. A running clearance is allowed between thrust-ring and bearing face.

Operation of Lucas Compression Drive

When the starter accelerates, the pinion lags through its own inertia, advances along the screw and meshes with the flywheel, when resistance to rotation causes the pinion to bear hard against thrust-ring and bearing journal. Continued turning effort of starter tends to screw the sleeve

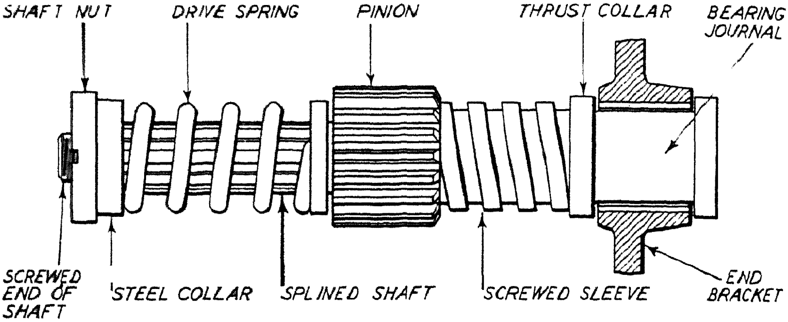


Fig. 2.—COMPRESSION DRIVE (INBOARD PATTERN)

out of the pinion. As the latter cannot move farther endwise, the sleeve moves along the shaft, compressing the spring against the shaft nut—the nut also having a hard-steel thrust-ring. This provides a degree of cushioning to absorb the torsion strain on initial engagement.

When the engine starts and overruns the starter, the pinion acceleration eases the thrust pressure, the sleeve screws in under spring pressure, and the pinion rotation causes it to screw back and retreat out of mesh.

A Later Type

A later variation, now commonly used, is shown in Fig. 3 as an outboard drive. A bearing collar replaces the shaft nut, the thrust direction is reversed, and a pinion guide sleeve is fitted, with shorter screwed sleeve. A light wire spring is interposed between the bearing collar and pinion, embracing the guide sleeve. The spring is compressed by the pinion travel on engagement, but assists the retreat of the pinion and prevents

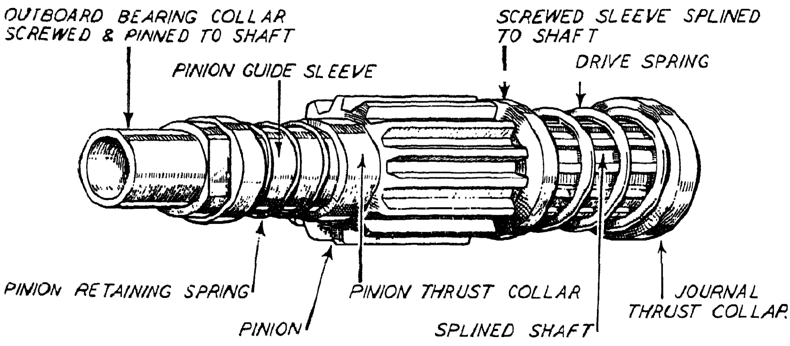


Fig. 3.—COMPRESSION DRIVE WITH PINION GUIDE AND RETAINING SPRING (OUTBOARD PATTERN)

creeping along the sleeve when the engine is running. A collar formed on the pinion, or separately assembled, has an internal bore to enclose the release spring when the pinion is fully meshed, also conveying the pinion thrust to the bearing collar. Note that in this design, the main spring carries the thrust load, but the drive torsion is transmitted from the shaft to pinion via splines.

Delco-Remy Clutch Drive

Another design with interesting features is the Delco-Remy clutch drive. The sleeve is splined to the shaft but is not on a screw. A housing fixed to the back of the pinion contains a free-wheel roller clutch, which transmits drive from sleeve to pinion. A grooved collar, freely mounted on the sleeve, is held against a flange thereon by a wire compression spring. A forked lever, pivoted to a stud on the starter carcass, embraces the grooved collar, small rollers being fitted at the fork ends and bearing against the collar flanges.

Operation of Delco-Remy Clutch Drive

Engagement of drive is direct by lever action, the fork sliding the sleeve assembly along the shaft to engage the pinion with the flywheel gear teeth while the starter is stationary, the switch action being intercoupled with the lever. The switch is closed by the lever when the drive is engaged and the starter accelerates under full load. If the teeth do not mesh the lever slides the grooved collar along against its spring, when the switch is closed, and starter rotation meshes the pinion, while the sleeve simultaneously slips forward under spring urge. Should disengagement be delayed when the engine starts, the pinion overruns the starter shaft and the free wheel uncouples pinion and sleeve so that increased speed is not transmitted back to the starter shaft. The free-wheel unit comprises inner and outer members, a number of rollers occupying the annular space between them. The inner member has a number of inclined faces resembling the teeth of a ratchet

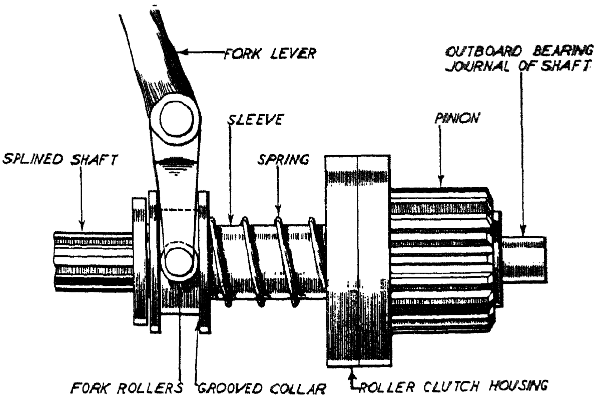


Fig. 4.—DELCO-REMY CLUTCH DRIVE (OUTBOARD PATTERN)

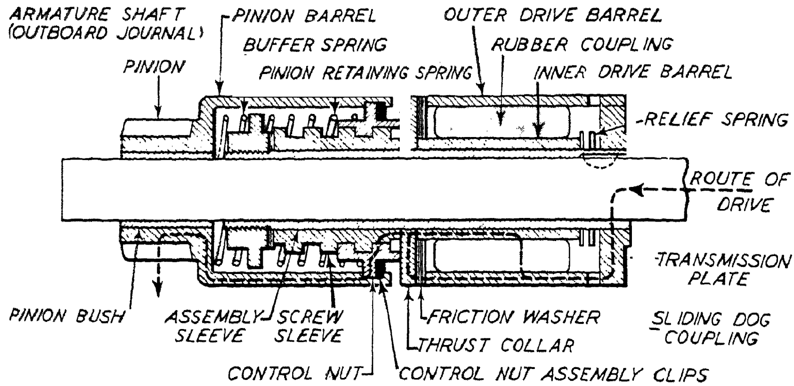


Fig. 5.—RUBBER DRIVE (TYPE RU.910)

wheel, and when drive is transmitted the rollers advance up these inclines, being wedged between their surfaces and the bore of the outer member. On reversal of stresses the rollers move down the inclines and relieve pressure on the bore of the outer member, which is then free to slide over the rollers, there being no coupling between the two members. Fig. 4 illustrates the main features of this form of drive.

Rubber Drive

A recent Lucas development which is being increasingly used on new models is the rubber drive, the outstanding feature of which is the use of a rubber bush or coupling, tightly wedged between the driving and driven members. This transmits torsion from starter to engine, acts as a resilient buffer, and provides a sort of " safety fuse " in the event of severe overload by shearing, thus preventing a bent or twisted shaft, burst windings, or cracked end brackets, otherwise possible under overload conditions.

Another feature of the design is the use of a pinion barrel enclosing the drive, the pinion being secured to its end, instead of riding direct on the screwed sleeve. This enables a smaller pinion to be used, with increased ratio between starter and engine, and greatly improved starter efficiency, with less current consumption.

Referring to Fig. 5, which shows outlines of the RU.910 drive, it will be seen that the armature shaft is plain, with a long sleeve keyed to it. At the inner end a transmission plate is splined to the sleeve and coupled by dog clutch to the end of the outer drive barrel. This, with the inner drive barrel and the intermediate rubber coupling, forms a single component ; a free sliding fit on the sleeve. The end of the inner barrel remote from the transmission plate (from which it is separated by a flat-coil relief

spring) is dog-coupled to the screw sleeve, a hard-steel thrust-collar also dog-coupled to both members. The pinion barrel, carrying the pinion, is secured to the control nut, which moves along the screw against the compression of the restraining spring, the purpose of which is to prevent creeping into mesh.

Operation of Rubber Drive

The action is as follows: When the starter accelerates, the pinion barrel lags and advances along the screw, against the restraining spring. End thrust causes the sleeve assembly to retreat, compressing the relief spring, the thrust-collar pressing the interposed friction washer against the outer drive barrel. The initial stress of engagement is taken by a rubber coupling which twists slightly to absorb the torque. When the sleeve assembly retreats, the pressure of the thrust collar and the friction washer enables some of the driving effort to be transmitted direct from the outer barrel to the screwed sleeve. The dotted line shows the route of drive transmission.

C.A.V.-Bosch Axial-engagement Drive

A form of drive commonly used on large commercial installations is the C.A.V.-Bosch axial-engagement drive. The design is such that the pinion is held against rotation by a plate clutch until it has advanced and meshed with the flywheel teeth, when the end thrust is imposed on the spring, which holds the clutch engaged. The latter is disengaged and the pinion is free to turn. The traverse of screw movement is comparatively short, as the starter armature moves endwise against a spring.

The design of the starter provides for dual switch movement. The first position energises the shunt fields, causes slow armature rotation and axial movement, the pinion advancing without rotating until meeting the flywheel. This ensures quiet definite engagement with flywheel gears. The pinion being meshed, the second switch position is operated by a latch controlled by armature travel, when the series fields are connected and full power exerted. When the main switch is opened, the retaining spring draws the armature and pinion back to the starting position.

SERVICE INFORMATION

Pinions and screw sleeves are of hardened steel to resist wear. When dismantled, the parts should be well cleaned in petrol and examined for cracks, chipping, or other damage. Pinion teeth usually have chamfered edges to facilitate meshing. If these are worn or burred the part should be replaced.

Whenever a starter with worn or damaged drive is repaired, the flywheel gear ring should be closely inspected, and, if teeth are damaged or broken, should be condemned for replacement; otherwise, new drive

parts will have short life and there is risk of more severe damage to starter.

Compression-type drive springs should be sufficiently compressed when the drive is assembled to prevent hammering thrust-collars on initial torque.

Weak springs will set shorter than a new sample, and should be replaced.

The light return spring on Lucas "S"-type drive should promptly return the pinion to rest from engagement position. If sluggish, check for distortion, weakness, or flattening of the brass ring between spring and pinion face, renewing defective parts.

Light, non-gummy machine oil may be used sparingly on screw sleeves of drives enclosed in the clutch housing of the engine, but exposed drives should be assembled dry, or lightly coated with black-lead or graphite.

Adjust end play in the starter shaft and see that only correct hardened rings are fitted to receive end thrust.

Outboard and Inboard Drives

In outboard drives, thrust is against the exterior face of the end bracket; in inboard drives, thrust is against the interior face. Where a pressed-steel centre bracket is fitted to outboard starter, this should receive thrust, not the outboard-bracket bearing face. If end play is excessive, hardened steel shims are supplied for adjustment.

Wear may occur on the thrust face of the screw thread on the sleeve and also in the pinion, when a new pair should be fitted. This wear is a frequent cause of sticking in mesh. Pinion and sleeve should be fitted as a pair—not singly.

Testing Rubber Drive

The rubber drive is checked with the starter on a test bench by winding the pinion fully out and locking against rotation with a lever, while the motor is momentarily switched on. The drive should withstand the resulting torque. Shearing of the drive may be due to wear of the friction washer, causing the rubber coupling to transmit full load. Washer should always be renewed when the drive is dismantled.

"Bendix" springs break through overload or backfire. Check ignition timing if trouble is recurrent. Always use new tab-washers to lock spring-fixing studs. If the ring-weight is loose on pinion, sleeve collar loose, or thread faces worn, condemn the pinion-sleeve assembly. Always check starter action and see that shaft is not bent or twisted.

ELECTRICAL TESTING WITH MODERN EQUIPMENT

By S. G. MUNDY, M.I.E.E., M.I.A.E., M.I.M.T.

THE apparent variation which exists between various makes of electrical testing equipment ceases to be a complication if it is realised that basically every item of test equipment comprises a number of standard instruments—usually the following:

Voltmeter.
Ammeter.
Sparkmeter.
Motor-driven contact breaker.
Master ignition coils.
Master ignition condenser.
Ohmmeter.
Condenser tester.
Syncroscope.
Exhaust-gas analyser.

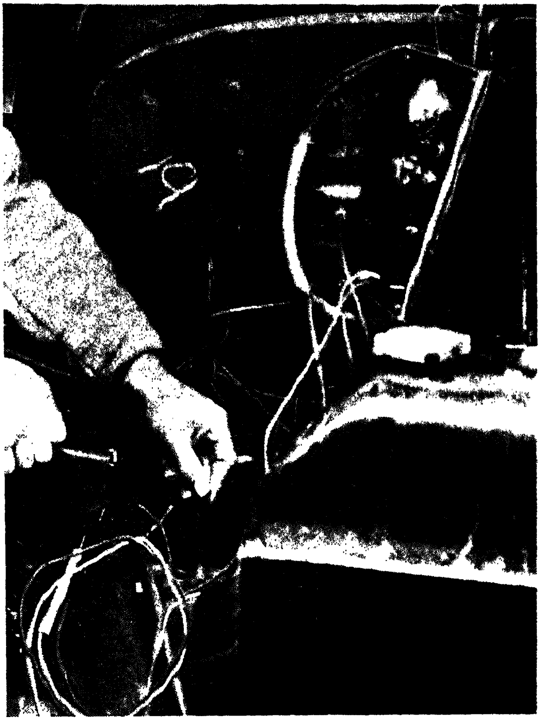


Fig. 1.—CONNECTING ELECTRICAL TESTER

A 6-volt tester (Electro Trouble Shooter) being connected to the car battery by attaching the red wire to positive of battery and the black wire to earth. Some of the tests that can be carried out with this tester can be seen in subsequent illustrations. (*Equipments Ltd.*)

The number of instruments fitted to any particular test set varies. We may have a test unit which comprises only a voltmeter, or perhaps a voltmeter and ammeter. We may be content to use separate portable instruments throughout, or in the case of complete testing panels, we may have the whole of the above instruments incorporated in a single unit.

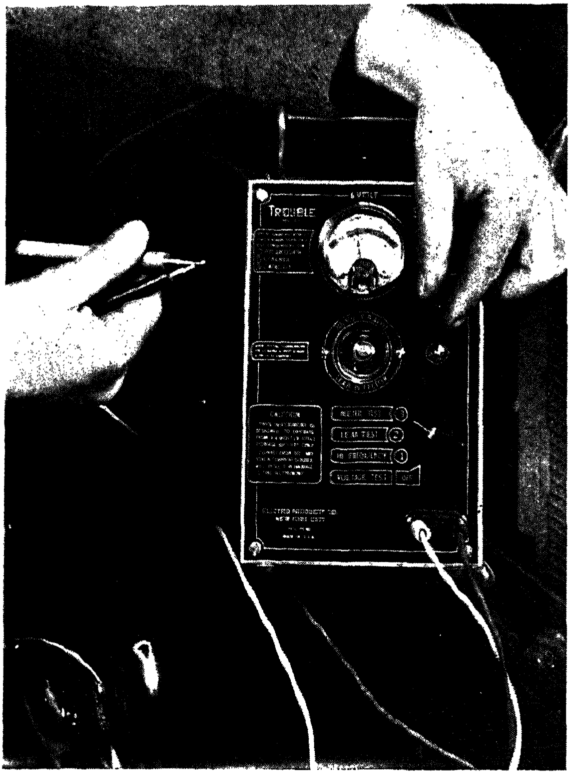


Fig. 2.—ADJUSTING METER OF TROUBLE SHOOTER FOR CONDENSER TESTING

The capacity of the condenser is to be tested. The test prods are being held together while the control is being adjusted until meter pointer is on "set." The test is then carried out as in Fig. 3. This instrument is a self-contained unit for detecting a short or leak in any electrical circuit and then determining its exact location. Incorporated also are features for testing various electrical components, such as condensers, distributors, coils, rotors, etc., which must be up to standard.

The apparent variation which exists between various makes of test equipment is, therefore, not so complicated as appears at first sight. If we acquire a fundamental knowledge of the use of the individual instruments which make up the complete test apparatus, we shall be able, without difficulty, to make the best use of the equipment in carrying out tests and inspections of automobile electrical systems and equipment.

In this article we examine very briefly the individual instruments and their methods of use, so that with this knowledge we shall be able more effectively to make efficient use of any particular make of equipment with which we may be called upon to deal.

The Use of a Voltmeter for Electrical Testing

The voltmeter is the most important instrument the garage mechanic will be called upon to use in automobile electrical work. It is essential that the fundamental characteristics of the instrument should be properly understood.

Fig. 3.—CONDENSER TESTING WITH SWITCH SET AT "METER TEST"

A voltmeter, as the name implies, measures voltage. It must, therefore, be connected *across* the circuit to be tested and not *in series* with the circuit, as in the case of an ammeter. If we are testing the dynamo voltage, one voltmeter terminal must be connected to the positive terminal and the other voltmeter to the negative terminal of the dynamo; or if the machine is earth-return, one voltmeter terminal to the "live" dynamo terminal and the other voltmeter connection to "earth."

In testing a battery, one voltmeter terminal is connected to the positive post of the battery and the other voltmeter connection made to "earth" or the battery negative terminal.

There are so many uses for a voltmeter in testing and analysing the electrical equipment on the car that its use can be adequately described only by a description of the most important individual tests which can be made. These tests are explained in other articles in this volume.

The Use of an Ammeter for Electrical Testing

An ammeter measures the flow of electric current in any circuit. It must, therefore, be connected in series in the circuit to be tested: the current in the circuit must flow through the ammeter.

In testing the current output of a dynamo one lead is removed from the dynamo terminal and this lead is then connected to one terminal of

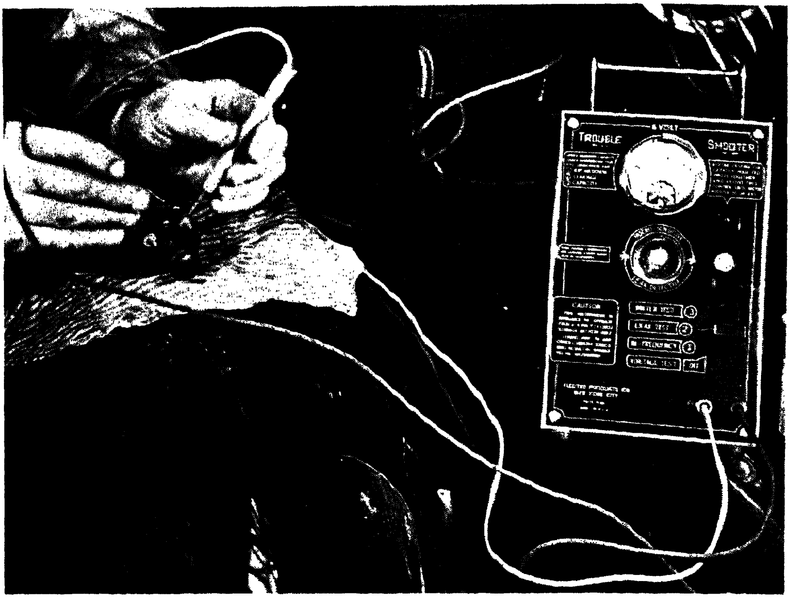


Fig. 4.—TESTING COIL FOR PRIMARY CIRCUIT LEAKAGE WITH ELECTRO TROUBLE SHOOTER

The trouble shooter is equipped with a micro-sensitive leak detector, shown in the centre of the instrument. This glows if a leak is present. When a leak is detected by the leak detector the exact location of the leak is determined by switching to the high frequency circuit, the discharge of which causes any high resistance leak or path to glow and sparkle such as in the distributor cap (see Fig. 5). The trouble shooter is made in two models—one for connection to any 220-volt A.C. line and one for connection to any 6-volt battery—by attaching the red wire to the positive of the battery and the black wire to the negative or earth.

the ammeter ; the other ammeter terminal is connected to the dynamo terminal from which the original wiring lead was disconnected.

There are many uses for an ammeter in electrical testing, including measurement and adjustment of charging rate, checking of current consumption, measuring current consumption of lamps and accessories, and checking the accuracy of switchboard instruments.

These tests are described in greater detail in subsequent articles.

The Use of a Sparkmeter for Ignition Testing

A sparkmeter in the form of a variable spark-gap is, in effect, the equivalent of a high-tension voltmeter. Its function is to measure the voltage value of the high-tension current at any point in the ignition system.

The accuracy of a sparkmeter depends upon the fact that the length

Fig. 5.—SHOWING ACTUAL LEAK IN DISTRIBUTOR CAP

Located by H.F. Test No. 1 tap on trouble shooter illustrated in Fig. 5. The leakage path is clearly seen in the above picture.

of an electric spark in air is equivalent to the voltage which produces the spark.

By calibrating the length of gap in millimetres, an indication of high-tension voltage can, therefore, be obtained at the ignition coil, the distributor plug leads, and at the plugs themselves. In this way the ignition high-tension system can be satisfactorily checked over, and verification obtained that it is in satisfactory condition.

Tests can be made to ascertain whether the full value of high-tension is being applied to the sparking plugs themselves. The plug leads can be tested by measuring the spark length or high-tension voltage at the end of each lead. The distributor and the ignition coil can be similarly tested.

Motor-driven Contact Breakers

Many electrical test sets, particularly those sold as coil and condenser testers, are fitted with a variable-speed motor-driven contact breaker. Usually this class of equipment comprises a variable-speed motor, a contact breaker, and a master ignition coil and condenser.

Ignition coils can be separately connected up to the test unit and operated under generally similar conditions to those experienced on the car, the engine contact breaker being replaced by the motor-driven contact breaker in the test set.

Comparative tests can be made of a condenser by comparing the results of the condenser as fitted on the car by its temporary replacement

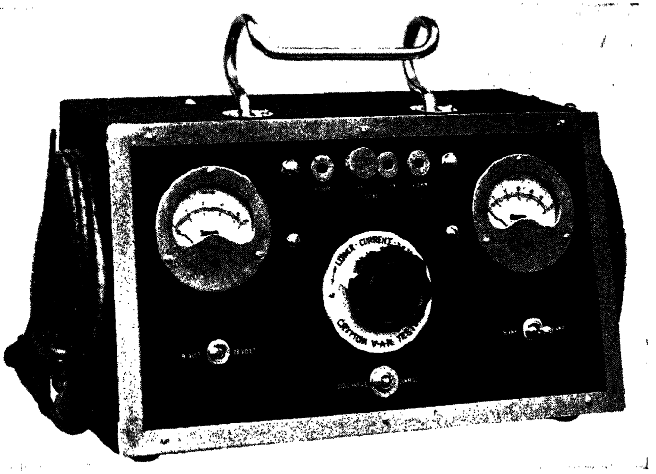
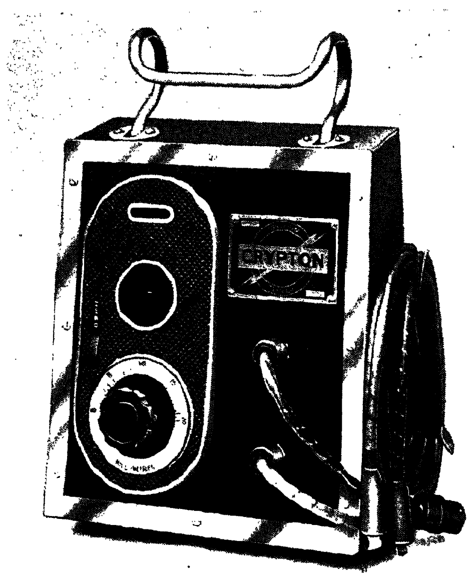


Fig. 6.—V.A.R. TEST SET

This set includes a voltmeter (0–30 volts) and ammeter (0–30 amps.) and a loading resistance with rotary control. (*Crypton Equipment Ltd.*)



by a simple switching operation with the master condenser as fitted on the test unit.

Standard test sets of this kind are usually designed to enable coils and condensers to be tested either on or off the car, if necessary connecting leads and switches being provided.

Condenser Test Meters

As an alternative to testing condensers by the

Fig. 7.—PORTABLE IGNITION TESTER

This comprises an adjustable 3-point balanced spark gap, and neon tube, for testing sparking plugs, high tension leads, distributor, ignition coils and condensers. (*Crypton Equipment Ltd.*)

comparative or substitution method, a separate condenser test meter can be used. This usually takes the form of a microammeter which measures the value of charge and discharge current.

Direct current is used for the test which, in the case of alternating-current sets, is obtained through a small metal or valve rectifier which gives a direct-current voltage (with a very small current) of from 300 to 500 volts according to the make of condenser test meter used.

Fig. 8.—MOTOR-OPERATED IGNITION TESTER

This is fitted with a motor-driven contact breaker, for 6- or 12-volt battery operation, ammeter, spark gap, rotary switches, testing leads, 6- and 12-volt master ignition coil, a master condenser and a special fixture for testing magneto armatures. (*Crypton Equipment Ltd.*)

The condenser to be tested is connected up to the meter and is first charged by throwing over a switch into the " charge " position. This causes the instrument needle to flick over, and the maximum reading which the needle obtains is an indication of the capacity of the condenser. The switch is now thrown over to a " discharge " position which discharges the condenser, causing the needle to return to zero. If it fails to return to zero it indicates a leak, and the amount of leakage will be the amount by which the needle is off zero.

A slight leak is usual, but should not exceed 5 microamps. An open-circuited condenser will give no reading. A short-circuited condenser will give a full-scale reading, and the needle will not return.

It cannot be claimed that a condenser test meter of this kind is 100 per cent. accurate, because, for complete testing, conditions due to heating and vibration must be considered. In practice, however, the use of a condenser test meter will give sufficiently good results to deal with all

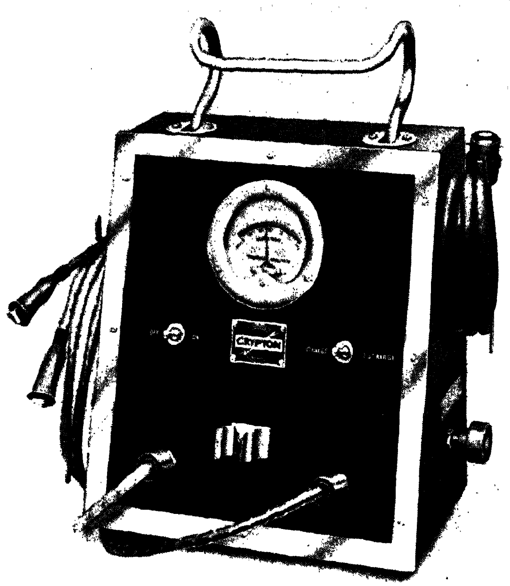


Fig. 9.—PORTABLE CONDENSER TESTER

This indicates if condenser is leaking and the amount of leak. It is connected to alternating current mains. (*Crypton Equipment Ltd.*)

normal requirements, particularly if the condenser when being tested is tapped in order to cover the possibility of an internal loose connection.

The Use of an Ohmmeter

Some modern items of test equipment are fitted with an ohmmeter, for the measurement of insulation resistance, and also to obtain a direct reading of the resistance of circuits such as field coils and solenoid windings.

For automobile testing work such ohmmeters are usually provided with direct current at 200 or 300 volts, obtained in the case of an alternating-current supply through a valve or metal rectifier. In some cases, however, a separate gear-driven dynamo is employed, such as in the case of the well-known "Megger" insulation tester.

Distributor Synchroscopes

The stringent conditions under which the distributor operates, and the necessity on the modern car of correct distributor adjustment, have resulted in the development of distributor synchroscopes for testing and adjusting the distributors under working conditions.

With automatic advance and retard it is very necessary to ensure that the automatic-advance mechanism is operating correctly. A mechanical-distributor fault will cause unsatisfactory engine performance.

It is impossible properly to test and adjust the distributor on the car, and for satisfactory results it should be removed from the car and connected to a variable-speed motor, preferably being mounted vertically, as is now usual in service. The variable-speed motor drives three-point static spark gaps, which rotate over a disc calibrated 360°. With this arrangement a distributor can be driven at varying speeds, and the exact

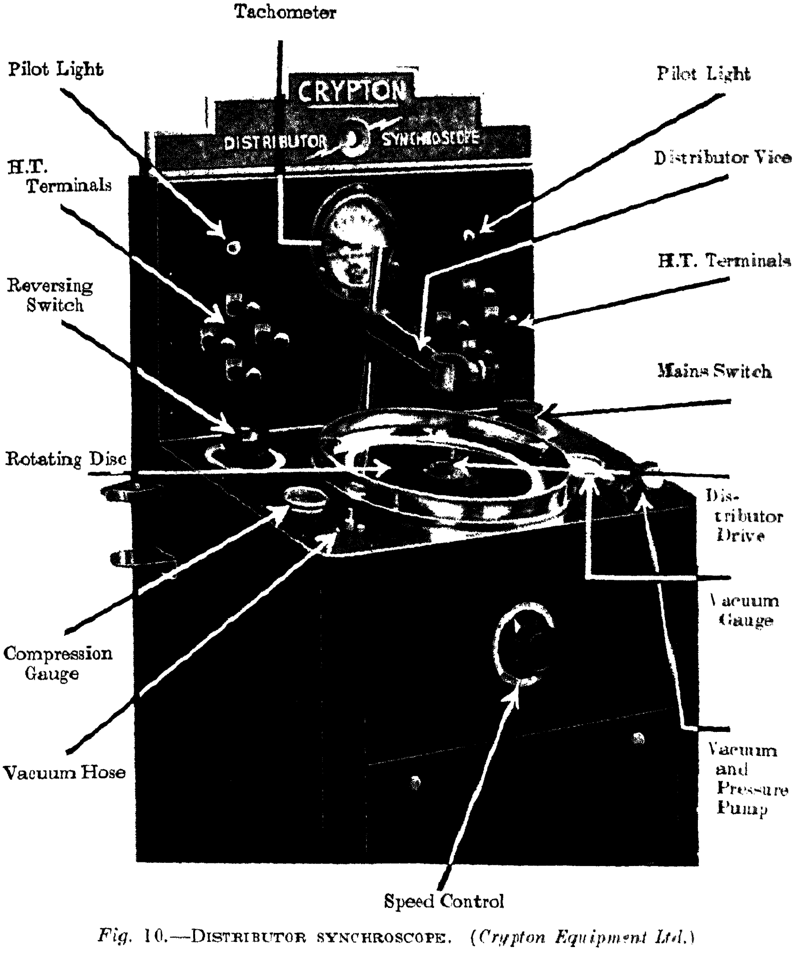


Fig. 10.—DISTRIBUTOR SYNCHROSCOPE. (*Crypton Equipment Ltd.*)

period at which the sparks take place can be read on the calibrated disc.

A correctly adjusted distributor for a four-cylinder engine should give four equally spaced sparks at zero, 90°, 180°, and 270°. Automatic advance can be checked by noting the point at which the advance cuts in and the number of degrees of advance as the distributor drivng speed is increased. A check can be made against the manufacturers' data, and it can be verified if the performance is satisfactory. If adjustments are necessary, they can be made and the results noted at the same time.

Fig. 11.—USING EXHAUST-GAS ANALYSER
The engine is warmed up and the sampler tube inserted into exhaust pipe.

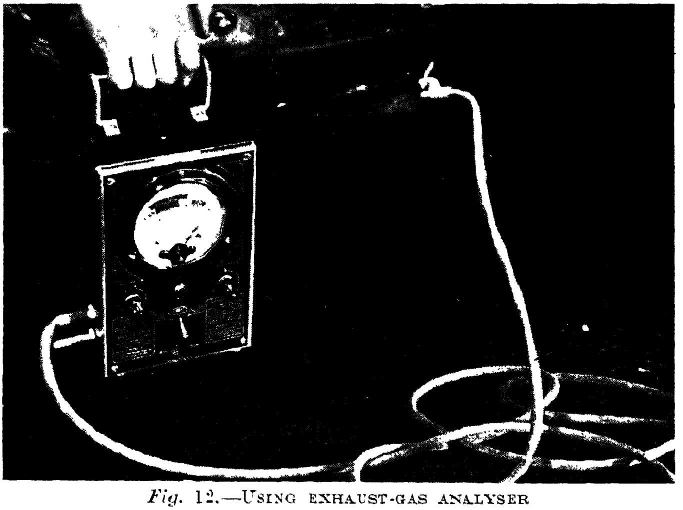


Fig. 12.—USING EXHAUST-GAS ANALYSER
Showing sampler tube clamped into place on the upper edge of pipe. The set can then be taken to the front of the car and hung in a convenient position near the engine.

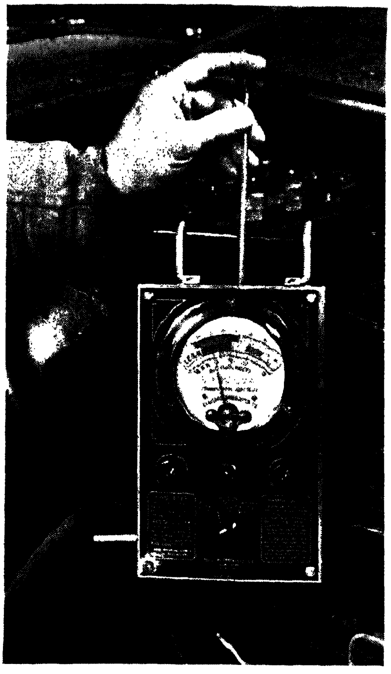


Fig. 13.—USING EXHAUST-GAS ANALYSER

The next step is to remove residual exhaust gas from the analysing cell by a few strokes of the aspirator, prior to setting the meter for test.

Fig. 14.—USING EXHAUST-GAS ANALYSER

First operation in setting the meter for the test. With the switch at "set" position, the needle is adjusted to read "10" by means of the left-hand rheostat.

Exhaust-gas Analysers

A lot of attention has recently been given to the use of exhaust-gas analysers for checking carburation efficiency.

Carburettor testing up to the present time has largely been a matter of guesswork, but to-day the service mechanic has available for his use, firstly, a vacuum gauge, which has already been described, and secondly, an exhaust-gas analyser.

The standard exhaust-gas analyser consists of an indicating meter calibrated in three divisions—"lean," "normal," and "rich."

The instrument is connected by means of a hose to the exhaust pipe, from which a sample of the exhaust gas is taken and passes to the analyser housing, usually through a separator where the water and most of the dirt are taken out.

Within the analyser housing the exhaust gas sample is mixed with air

Fig. 15.—USING EXHAUST-GAS ANALYSER

The second operation in setting the analyser is to switch to "test," and to adjust the needle to read "13" by means of the right-hand rheostat.

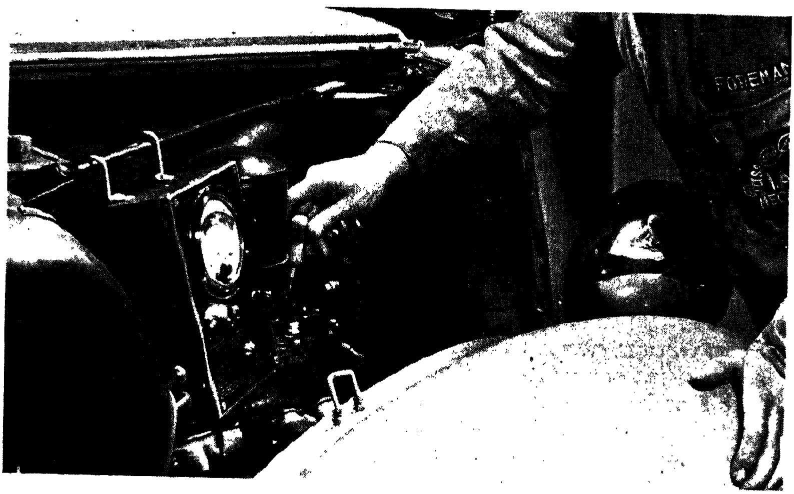


Fig. 16.—USING EXHAUST-GAS ANALYSER

orrect reading. Fig. 17 shows a good

and is passed over an element which consists of four platinum wires. These wires are heated by an electric current supplied from a battery incorporated in the analyser housing. Two of the wires are active, and the other two wires are treated to render them inactive.

If the exhaust gas contains combustible vapour, the active wires begin to glow. This increases their electrical resistance and gives a reading on the meter. This reading will be in proportion to the amount of combustible gases in the exhaust.

The meter is calibrated in per-cent. completeness of combustion, so that an indication is obtained of the percentage efficiency of carburation.

Exhaust-gas-analyser tests should be made with the engine at normal working temperature. In making tests, the adjustments provided for should be made to correct a pressure of more than 2 on a pressure-gauge fitted to the analyser.

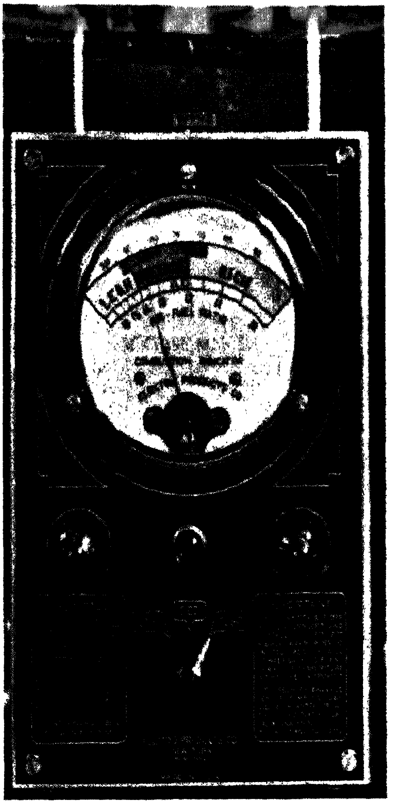


Fig. 17.—A GOOD READING TO OBTAIN FOR ECONOMICAL RUNNING ON EXHAUST-GAS ANALYSER

The analyser shown in Figs. 11-17 is the Mixture Master. (*By courtesy of Equipments Ltd.*)

The engine is now run at a speed of approximately 45 m.p.h., and the operator should note the indications on the meter scale ; the instructions provided with the instrument will indicate to the operator the efficiency of carburation and the necessity of any service which may be required.

The design of the engine may have some influence on the result obtained with the exhaust-gas analyser and, in case of doubt, it is advisable to get in touch with the makers of the equipment.

DYNAMOS AND CHARGE CONTROL SYSTEMS

By E. T. LAWSON HELME

Field Windings

AUTOMOBILE dynamos were originally evolved from railway-train lighting and industrial direct-current machines, having a common purpose of accumulator charging. All machines in this group must be self-exciting—that is, capable of building up voltage from nil, from a standing start, without external current supply for energising the fields. It follows, therefore, that there must be some primary weak field in which the armature rotates and commences to generate, and this is produced by the residual magnetism remaining in the iron pole shoes. The low voltage generated in the armature by rotation in this weak "permanent" field is applied to the field windings, which then set up a flux to supplement the primary field, and a progressive build-up of density results, correspondingly increasing the armature voltage to its maximum.

Magnetic Circuits

Like an electrical circuit, a magnetic circuit is regarded as a continuous path round which lines of flux-density flow. Figs. 1 and 2 show two common arrangements, two-pole and four-pole assemblies respectively.

In Fig. 1 the left-hand pole shoe assumes N. polarity, lines flowing through the armature core to the right-hand pole shoe, which assumes S.

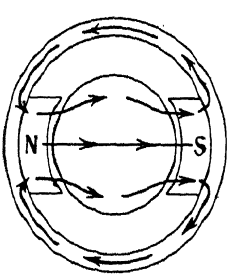


Fig. 1.—MAGNETIC CIRCUIT—TWO-POLE DYNAMO

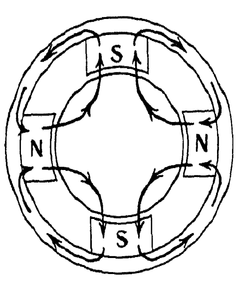


Fig. 2.—MAGNETIC CIRCUIT—FOUR-POLE DYNAMO

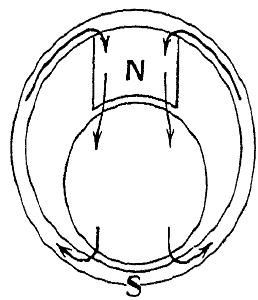


Fig. 3.—ANOTHER FORM OF TWO-POLE ASSEMBLY

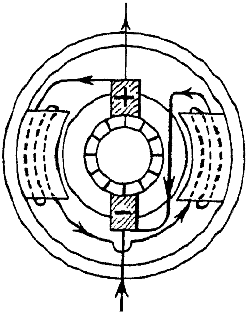


Fig. 4.—SHUNT WOUND, TWO-POLE ASSEMBLY

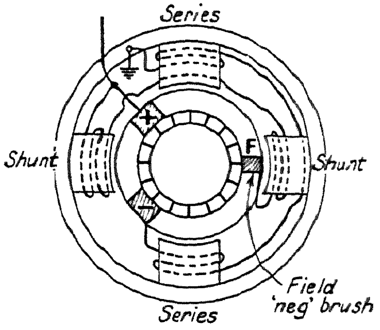


Fig. 5.—DYNAMOTOR CONNECTIONS

polarity, the lines continuing in two paths round the iron yoke or carcass back to the N. pole.

In Fig. 2 four poles are used. The left and right pole shoes are both N., and the upper and lower both S. Lines flow in four paths, as shown, entering the armature core from each N. pole and dividing upwards and downwards to each S. pole, with return paths through the carcass.

Fig. 3. shows another form of two-pole assembly, used in dynamos with shaft centre eccentric to the carcass centre. Only one pole carries a winding, the other being integral with the carcass, and referred to as a " consequent " pole. Lines flow from wound N. pole (top) to unwound consequent pole (bottom) via the armature core, returning through the carcass.

Winding Connections

Fig. 4 illustrates a " shunt wound " two-pole assembly. Note that the two field coils, or windings, each embracing a pole shoe, are connected in series, the two outer connections being taken to positive and negative brushes. The field circuit is therefore in parallel with the armature and receives the full generated voltage, the construction being used in all plain battery-charging dynamos to ensure self-excitation and steady output under varying loads.

Dynamotor Connections

In a four-pole shunt-field circuit, the four coils are in series, with the entry lead of the first coil and the exit lead of the last coil connected to main positive and negative brushes. This arrangement is not used in starters, as the requirements are entirely different, but in dynamotors, which combine starting and generating functions, the field design is modified as illustrated in Fig. 5. In this case a four-pole field is used, comprising two pole shoes carrying shunt-connected windings, placed on

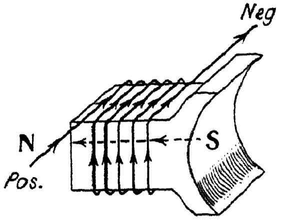


Fig. 6.—SHOWING RELATION BETWEEN CURRENT AND MAGNETIC FLUX

This relationship is important in checking field connections.

opposite sides, while the remaining two pole shoes carry coils connected in series with each other, and also in series with main armature circuit. Thus, when the machine is used for starting, battery current enters the main terminal, passes to the positive brush, via the armature windings to the negative brush, and round the series field coils to carcass "earth" connection, and thence back to battery via the chassis. When the machine is running, residual magnetism causes voltage build-up and current is shunted from main brushes round the shunt-field windings. The machine then generates. It is important to note that both shunts are of one polarity and both series of the other.

When starting, a small shunt-field current flows from the battery voltage at the main brushes, but its influence on the field flux is negligible compared with that of the series poles.

Similarly, when generating, charging current traverses the series field windings *en route* to battery, but again its comparative flux is negligible. The shunt-wound poles therefore act as consequent unwound poles to the series when starting, and the series-wound poles become consequent to the shunt poles when generating, preserving four-pole characteristics, hence the like polarity of each pair of windings, with unlike polarity to each other.

A further development of dynamotor design is the six-pole machine with three shunts, of like polarity, alternately positioned with three series, again of like polarity. All the shunts being N., all the series will be S. poles. There are six flux paths through the armature core and carcass, the design being a development of four-pole practice.

Direction of Winding

It must be carefully noted that the direction of winding decides the polarity of the resulting induced field. Fig. 6 shows the law governing this, which may be briefly defined thus: Looking endwise at an electromagnet, current flow (from positive to negative) round winding in a clockwise direction produces a field with " south " pole towards the observer and " north " pole away from observer, who is looking in the direction of the flow of magnetic flux lines. Reversal of positive and negative connections, or reversal of current direction, results in a field with N. towards observer and S. away from observer. This should be memorised, as it is important in checking field connections.

Fig. 7 illustrates how four field coils are wound for shunt connection. It should be noted that the two ends of each winding are commonly

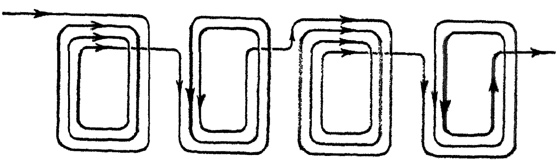


Fig. 7.—HOW FOUR FIELD COILS ARE WOUND FOR SHUNT CON-

referred to as "entry" and "exit" leads, according to direction of current flow. For example, current enters the left-hand coil from the positive brush connection, at the outside end, traverses the turns to the inside end, the "exit" lead being brought across the turns and insulated therefrom. This end is connected to the "entry" lead of the next coil, which starts at the outside turns, and current leaves at the inside exit lead. As these two coils are wound in opposing directions, or fitted on the pole shoes in opposing positions, unlike magnet poles are induced. The remaining two windings follow the same principle, the inside exit turns of second coil joining the outside entry turns of third, while inside exit of third joins outside entry of fourth. Polarity is decided by current direction only, and the use of inside or outside terminals is governed only by convenience and design.

Armatures

In all automobile dynamos, the angle between main brushes is the same as the angle between unlike field poles, and the armature must be wound with the same number of current paths. Armature windings are grouped under various classifications, such as "lap" winding and "wave" winding, each of which may be "progressive" or "retrogressive" in direction. Each coil or group of coils comes into the densest area of field flux twice, or four times per revolution, and its ends must be connected to the commutator bars which lie under main brushes at this instant. The voltage generated by the windings, which is then at peak value, is collected by main brushes and applied to circuits across them. This angle between coil sides and commutator connection is most important, and is described as winding pitch. Each coil may comprise several turns. Tracing the wire from any one commutator bar, it will be found to pass into one of the longitudinal grooves in the core, cross the back of the core to enter another groove, cross the front and re-enter the first, making several loops or turns before the end is finally brought out to another commutator bar. A number of such coils are wound on the core, the ends of each being brought out to bars which are an equal angular distance apart in each case. The coil sides, which occupy the slots, are the active sections, being the parts which "cut" the lines of magnetic flux, while the sections crossing at back and front are merely conductors and non-active in generation. As each coil in turn moves into the

densest flux, its respective commutator bars come under the brushes. Its place is taken successively by each coil in turn.

ARMATURE FAULTS AND TESTING METHODS

Faults

Assuming that an armature is of correct type for the dynamo to which it is fitted, defects which will prevent it generating properly may be classed as follows:

(*a*) Earthed windings or commutator.
(*b*) Shorts between windings, turns, or adjacent commutator bars; or
(*c*) High resistance or open-circuit faults.

Tests for Faults

The first fault can be detected by the use of direct-current mains test lamp or megger-type ohmmeter. The second and third are located by various methods operating on alternating-current or direct-current supply, the best known of which are the volt-drop comparative test on direct-current supply, and the induction comparative test, for use on alternating-current supply. In either case, the test is based on a comparison of the characteristics of each coil or group of coils in turn, results demonstrating whether these are equal within limits, indicating sound windings, or widely divergent, denoting faults of either (*b*) or (*c*) nature.

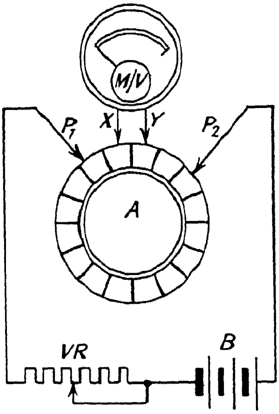


Fig. 8.—LAYOUT OF A "DROP TEST"

Battery B, variable resist- VR, prods X. Y '1, and M/V.

Making a Drop Test

Fig. 8 illustrates the layout of the "drop test," as it is popularly called. Current from the battery B flows through the variable resistance VR to prod $P1$, round armature (A) windings, leaving at prod $P2$, and returning to battery. As the prods contact the armature (commutator bars) at the same angle as main brushes—in this case the angle is 90°—two paths are offered: via the normal "live" coils or group of coils, and also via other windings in series. The actual length of wire or group of coils connected between any one bar and its neighbour is usually the same, and therefore the resistance between adjacent bars should be equal all round. This is verified by the millivoltmeter M/V, which is bridged across adjacent bars by the prods X and Y. When connected thus, current flows via alternative paths as the coils and the meter bridging them are in parallel.

The higher the resistance of the coils, the more current will be by-passed through the meter, and vice versa. As the resistance *VR* is adjusted to produce a definite reading of the meter on any one coil, the armature is moved round, bringing successive groups of windings under the prods. If the resistances of the windings are equal, meter readings will be the same for all. A coil with faulty connections introducing excessive resistance will cause a higher reading, while an open-circuited coil will allow the full voltage to be applied to the meter, resulting in possible damage to the meter unless precautions are observed.

On the other hand, shorted turns causing lower resistance will pass more current, the meter reading begin lower, while if the coils are shorted as a whole—such as by shorted commutator bars—the meter reading will be practically nil.

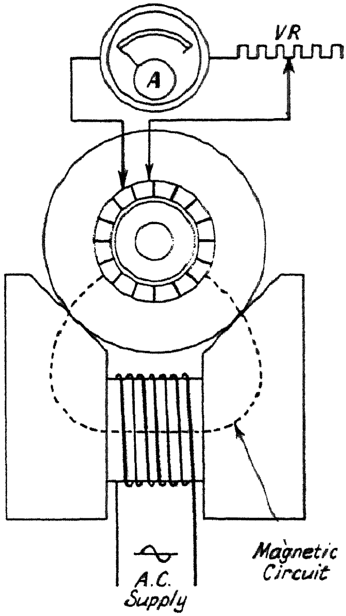


Fig. 9.—GROWLER TEST

It is essential to clean all dust or copper fragments from the mica insulation between commutator bars in order to get readings which are a true indication of the state of windings.

Check for Earthed Windings First

It is usual to check an armature for earthed windings (Fault *a*) first. If one prod of the test-lamp circuit is placed on the core and the other on any commutator bar, a faulty circuit affecting any of the windings will cause the lamp to light.

Growler Tests

The second comparative test—commonly known as the "growler" test—uses the armature as part of a transformer construction, the current generated in its windings being compared. Fig. 9 shows the diagrammatic layout. The growler laminated core carries a winding to which alternating-current voltage is applied. An alternating flux is induced, traversing an "iron" circuit of which the armature core, placed in the limbs of the growler core, forms part. Alternating voltages are induced in the windings, but practically no current flows, as the voltage surges in one group of coils are met by simultaneous opposite voltage surges in

other groups, this not necessarily being the case in all instances, as armature winding designs vary. The voltage induced in any one group connected to adjacent bars is measured by the current flowing in the ammeter and variable resistance when the prods are applied to these bars. The armature is turned round in position on the growler, each coil circuit being compared as adjacent pairs of bars come round.

It is important to note that the current generated by any one coil circuit varies with its position relative to the growler limbs. The test circuit, comprising ammeter, resistance, and prods, is applied to the coil circuit and the armature moved to give the highest reading within the meter range, current being adjusted by the variable resistance. Each coil circuit must then be tested in the same relative position to get true comparative results.

High resistance or open-circuits will produce lower meter readings as the current flow is reduced or interrupted.

Shorted turns may cause a higher reading owing to reduced impedance, and will also cause local heating.

Shorted bars will produce little or no readable current, but the fault may be revealed by local heating or smoke.

Shorted coils may also be detected by magnetic effect. If an iron "feeler"—such as a hacksaw blade—is laid on the top of the core as it is turned, a shorted coil with reveal its presence by increased magnetic pull on the feeler.

In both direct-current and alternating-current methods it may be found that modern armatures produce alternate high and low readings. This is due to winding design, and while the variation is regular and not too divergent, it should not be mistaken for a fault.

CONTROL METHODS

The shunt-field dynamo, when used for battery charging, develops a terminal voltage which varies with its speed, with a corresponding variation in the current flowing through the battery. As an accumulator of any given capacity will carry only a definite maximum charging rate without overloading and risk of heating, rapid evaporation of electrolyte, and eventual damage to its elements, so a dynamo used on a vehicle, where speed is always varying, must be equipped with means of limiting the charging rate within safe values at all speeds likely to be attained in ordinary use.

An early system of clutch drive, in which slip occurred above a certain speed, was the only attempt made at direct speed control, and was abandoned because of the practical difficulties encountered. All other systems since developed operate on electrical principles, and control output by the only practical means—limitation of voltage applied to the field circuit and resultant dose regulation of current and magnetic-flux density.

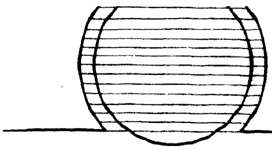


Fig. 10.—THIRD-BRUSH ARMATURE-REACTION CONTROL

This picture illustrates the direction of field flux at low output.

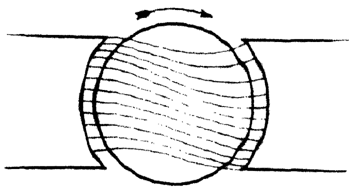


Fig. 11.—THIRD-BRUSH ARMATURE-REACTION

How the lines are distorted by the opposition of armature flux when output :

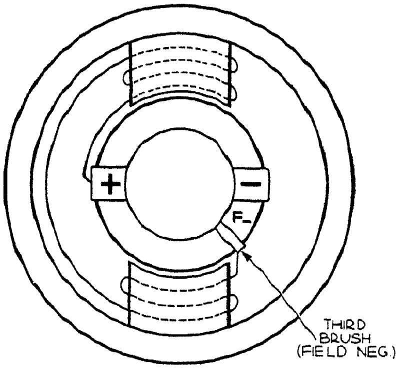


Fig. 12.—SHOWING THE THIRD-BRUSH AND FIELD CONNECTIONS OF DYNAMO CONTROLLED BY REACTION EFFECT

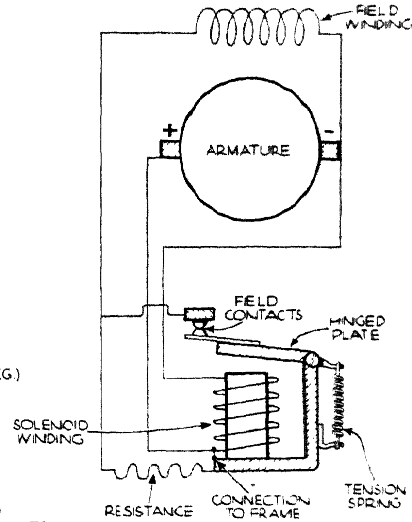


Fig. 13.—SIMPLE SOLENOID VOLTAGE CONTROL OF PLAIN-SHUNT DYNAMO

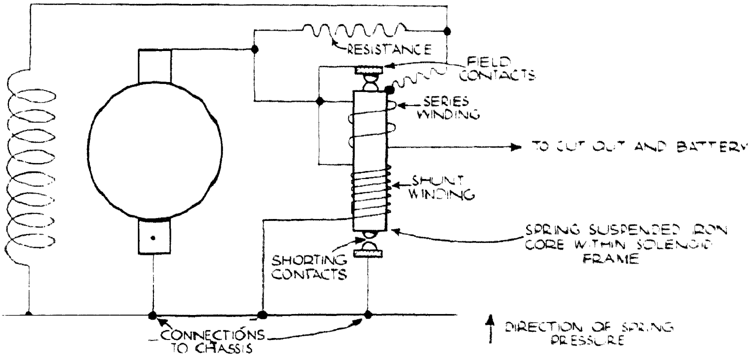


Fig. 14.—COMPENSATED-VOLTAGE CONTROL

Two main systems have been made use of, being designated " constant current " and " constant voltage " respectively. Designers have now very largely concentrated on the latter system, with several important modifications, although constant-current dynamos are still very commonly used, especially on small cars.

Third-brush Armature-reaction Control

Armature reaction is the magnetic flux generated by current flowing in the armature windings opposing the flux due to the fields, and causing a distortion of the lines of force traversing the armature core, the effect increasing with output. Fig. 10 illustrates the direction of field flux at low output, and Fig. 11 shows how the lines are distorted by the opposition of armature flux when output rises, the axis of the resultant lines of force across the armature being twisted round in the direction of rotation.

In a dynamo controlled by reaction effect, the field connections are not both taken to main brushes as in a plain-shunt machine, but one is connected to a third narrow brush bearing on the commutator at a position at an acute angle to one of the main brushes, as in Fig. 12.

The voltage between this third brush and the other main brush is therefore less than that between the two main brushes, the effect being that of " tapping " armature voltage. The armature coils connected to the commutator bars, from which field current is collected, are not passing the densest part of the field at low speed. As output rises, flux distortion tends to shift the axis—or densest part of flux—towards the position occupied by these coils, with corresponding increase of field voltage and flux. Further increase of output distorts the axis farther round, so that the dense area recedes beyond the position of the tapped armature coils, causing a fall in field-applied volts, current, and flux density. The two opposing factors of reaction distortion and field voltage balance each other over a wide range of speed, beyond which distortion gains the ascendancy and output falls with further increases of speed. The " flat-peak " value of dynamo-charging current can be varied by moving the third brush round in the direction of rotation to increase it, and against the direction of rotation to reduce output. The layout shown in Fig. 12 is that of a two-pole dynamo. In a four-pole machine, with two main brushes positioned 90° apart, the third brush may be adjacent to the position of either, or may be placed near the opposite angle of commutation—i.e. 180° from the main brush of same polarity.

The voltage at commutator bars in this position approaches maximum, although no main brush is fitted in this position. In other words, the four-pole armature has two positive and two negative maximum-voltage positions, although only one position of each sign feeds a main brush.

Solenoid-voltage Control

The inherent disadvantage of current control lies in the fact that current remains tolerably constant, whatever the state of charge of the

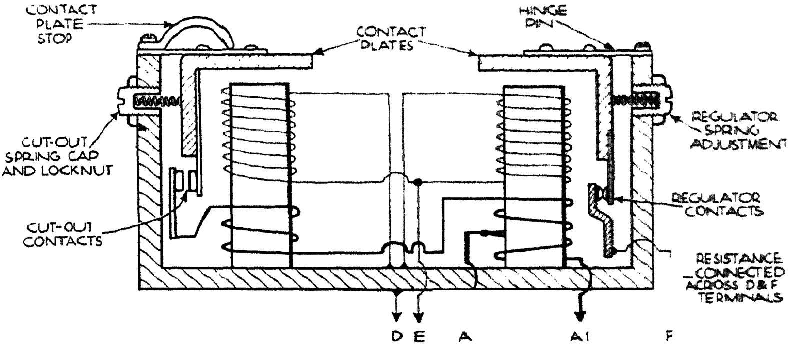


Fig. 15.—REGULATOR DESIGN USED IN LUCAS RF50 AND SIMILAR CONTROL BOXES

battery. In fact, with a fully charged battery, dynamo voltage rises in opposing and overriding battery back-e.m.f., field voltage is boosted, and the average output is higher—an undesirable condition from the viewpoint of battery welfare. Voltage control is designed to maintain dynamo volts up to, and at, a constant level, the charge-rate being in accordance with the back-voltage, or b.e.m.f., of the battery, so that the latter is charged at a rate suited to its needs.

Fig. 13 shows simple solenoid control, in which a plain-shunt dynamo with external field control is used. The solenoid winding is connected across main brushes, receiving armature voltage. The field circuit includes a pair of contacts—normally closed by spring pressure—and bridged by a resistance. One of the contacts is fixed, but the other is mounted on a hinged or spring-suspended iron plate or core positioned so that it receives the magnetic pull of the solenoid. In the open-type regulator—now commonly used—the solenoid frame resembles that of a cut-out, with the important difference that contacts meet when the unit is not operating ; the reverse to cut-out practice.

Operation of Solenoid-voltage Control

Operation is as follows : The closed contacts offer very little resistance to current flow and the field receives practically the full generated voltage. This voltage is also impressed on the solenoid winding of the regulator. which is energised and exerts a magnetic pull on the hinged plate, opposing and consequently weakening spring pressure on contacts. At a predetermined voltage, spring pressure is overcome and the contacts are separated, when field current is by-passed through the resistance and consequently decreased. Terminal voltage falls and solenoid flux weakens, when the spring regains the balance of force and contacts again meet. Field current rises again and the cycle is repeated in rapid succession, resulting in high-frequency vibration of the hinged plate and

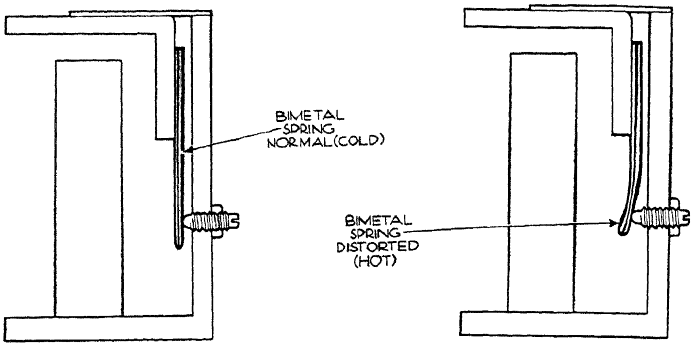


Fig. 16.—THE DISTORTION BY HEAT AND RESULTING EFFECT ON CONTACT PRESSURE (SHOWN EXAGGERATED FOR CLEARNESS)

A, bimetal spring (cold). B, bimetal spring distorted (hot).

contacts. The field current is therefore subject to rapid fluctuation as the result of regulator action, but this fluctuation is largely smoothed out by the impedance due to the magnetic characteristics and ampère-turns of the field windings so that the regulated current remains level over a wide range of dynamo speed.

The open-circuit (no-load) voltage at the terminals of a regulator-controlled dynamo is therefore constant, being about 15·75 volts in the case of a 12-volt set. The charging rate will be high when the battery voltage is low, but as the battery voltage rises the difference between this and the dynamo-terminal voltage diminishes until, when the battery voltage approaches 2·5 volts per cell on charge, the resulting rate of charge falls to a low value, which is the ideal aimed at in battery charging.

Fig. 14 illustrates another form of regulator using two pairs of contacts, the second pair being open in the idle position, and connected across the field windings. Regulation is effected by vibratory contact of the yield contacts, as already described, until dynamo speed rises above a certain limit. At this point the magnetic flux of the solenoid draws the iron core down so that the contacts are held apart, yield current passing via the resistance. Further increase of voltage causes the iron core of the regulator to be drawn in to full extent, when the second pair of contacts meets, and the field circuit is shorted through them.

Field flux collapses, voltage falls, spring pressure overcomes solenoid pull, and the shorting contacts separate, when field builds up again and the cycle is repeated at high frequency. This design is used in Lucas LR1 and LR2 regulators of the enclosed-barrel type.

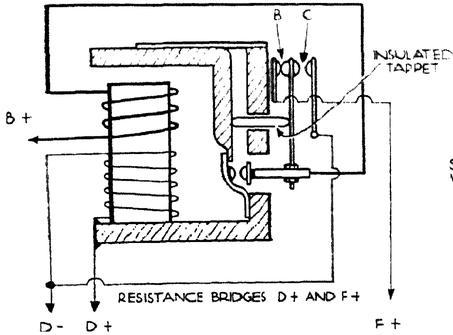


Fig. 17.—C.A.V.-BOSCH COMBINED CUT-OUT AND REGULATOR

Shunt and series windings function as both cut-out and regulator.

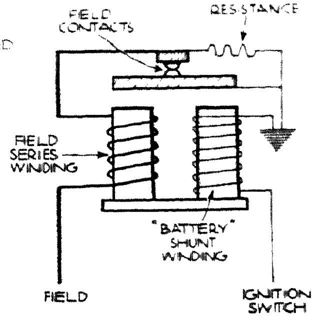


Fig. 18.—CURRENT-VOLTAGE REGULATOR TYPICAL OF AMERICAN PRACTICE

Series Compensating Windings

In Fig. 14, a second winding of heavy wire is drawn on the solenoid core, in addition to the fine-wire "shunt" winding. Current flowing to cut-out and battery traverses this "series" winding and exerts a compensating influence on dynamo-controlled voltage. If a dead cell lowers battery b.e.m.f., or a short across mains cables lowers the effective resistance of the battery line, regulator would maintain dynamo voltage at normal, and an excessive output would result, with no series winding. Where this output traverses a compensating winding, the latter automatically supplements the solenoid-magnet flux, and spring pressure is overcome at a lower voltage level, so that dynamo voltage is reduced in proportion to additional load, preventing overheating and burn-out. All regulators are now fitted with series compensating windings. It is to be noted that the shunt and series windings are in the same direction relative to current flow.

Fig. 15 shows the regulator design used in Lucas RF50 and similar control boxes. This has regulator and cut-out combined on a common L-shaped frame, each having a wound solenoid core and a contact plate, as shown, fitted by spring hinge. A spiral or flat spring with adjusting screw and locknut exerts pressure on each contact plate, holding the cut-out contacts apart—spring pressure maintaining the plate against the curved stop—and the regulator contacts together. Each solenoid has a shunt winding of fine wire connected between the common frame (dynamo "live" potential) and the *E* terminal. The cut-out has the orthodox series winding, and the regulator has a divided series winding, the two sections carrying current in opposite directions round the core. Current flows from common frame to *E* (earth), energising both cores.

In a 12-volt set, the cut-out closes at 12·75–13·5 volts, current flowing via cut-out series and the upper half of regulator series winding to terminal *A*—wired to ammeter and battery. Regulator action commences at 15·75–16·3 volts, unless a fault is causing excessive charging rate, when series flux brings regulated voltage to a lower value. The lower half of the regulator series winding is connected between terminals *A* and *A*1.

All consumer circuits other than starter and emergency-light sockets are fed from terminal *A*1, and therefore all discharge current must traverse the lower series winding. When lamps are switched on, therefore, the current flowing round this winding sets up a magnetic flux of proportionate density which opposes the fluxes of shunt and charge series. The result is that composite flux is weakened, regulation delayed, and dynamo voltage increased to compensate for lamp load.

Temperature Compensation

The latest Lucas regulators, bearing letters "LRT" with type number, have a special bi-metallic flat spring secured to the regulator contact plate, its free end bearing on the adjusting screw. The two metals forming the spring expand with temperature rise, but at different rates, so that the spring distorts with heat, its resistance to solenoid pull decreasing with rising temperature. When cold, the regulated voltage is high, giving a boosting charge to the battery, making up ampère-hours expended by the battery in starting. Rising temperature causes the spring to distort and exert less pressure on contacts, so that solenoid pull starts them vibrating at lower voltage and dynamo output falls accordingly.

Fig. 16 A and B shows in exaggerated form the distortion by heat and the resulting effect on contact pressure.

Single-core Combined Unit

Fig. 17 illustrates a combined cut-out and regulator used on some C.A.V.-Bosch commercial equipment, in which a single shunt and a single series winding operate both functions.

First movement of the contact plate causes cut-out contacts to close. Further solenoid pull overcomes spring pressure on the field contacts (*B*), which vibrate and control voltage at normal speed. At higher speed, solenoid pull draws the contact plate fully down, when the shortening contacts meet, bridge out the field circuit, and secondary regulation is established. The series winding, in addition to functioning as cut-out hold-on and discharge-current release in the ordinary way, also serves as regulator-charge compensating winding, as its flux supplements the shunt and lowers the regulated voltage when a safe maximum output is attained.

Current-voltage Regulation

The foregoing types all use a series winding enabling current flow to effect regulation according to battery condition. In American design, regulators are frequently fitted with separate series-wound cores. In 6-volt sets, where current values are higher, it is common practice for one core of the regulator unit to carry a winding in series with the dynamo field, the flux it produces being directly proportional to field density.

The other regulator core carries a shunt winding which is connected across the battery via ignition switch. Fig. 18 illustrates a layout of this type, and it is important to note that a three-brush reaction dynamo is often used, combining both systems of output control. These sets must be run or tested only with the battery connected, as open-circuit generating allows a dangerous voltage rise.

SERVICE INFORMATION

The following general hints will be useful in locating causes of dynamo or control trouble :

General-condition Test of Dynamo

Before removal from the vehicle, a general rough test can be made by disconnecting leads, running at moderate speed, and bridging *D* and *F* terminals with an insulated screwdriver or similar article, noting that a flashy spark occurs on breaking contact. This test imposes full voltage on fields, and must be applied with caution. A growling or whining noise on bridging terminals signifies worn bearings, loose poles, or other mechanical trouble revealed by magnetic pull. An insulated bridge is necessary, as field voltage on break may cause a shock if terminals are touched.

With the machine on the bench, dismantled, tests and inspection should include the following : Field conductivity, insulation to carcase, armature tested on drop-test or "growler" (alternating-current impedance comparison), insulation of windings and commutator to shaft ; brush-holder insulation to carcase, brush wear, friction in guides, brush-spring tension, yield leads and terminal contacts, soldered joints, etc., field intercoil joints, general state of windings, charred insulation (should be condemned even though tests appear satisfactory), bearing wear, shaft wear, mechanical damage.

These details apply to all types of dynamo. In addition, the following "don'ts" should be remembered and applied in practice to avoid high costs, lost time, and jeopardised custom :

Don't test insulation with mains-voltage lamp until carbon dust and oil are washed away and insulator dry and clean.

Don't hold armature in vice while applying heavy torsion to shaft nut. The core is splined to the shaft and may shear or shift under the strain.

If the nut cannot be tightened while the shaft is held, the spanner should be tapped rather than heavy pressure applied. Hold pulley or sprocket by a piece of belt or chain with ends secured in vice.

Don't grip small carcases tightly in vice. This may cause distortion out of round and result in rubbing on field poles.

Don't skim commutator with shaft out of truth or eccentric to lathe centre. It is better to arrange a small chuck to fit the lathe back poppet so that a bush of correct size can be used to support shaft by bearing journal, ensuring concentricity.

Don't leave internal screws any chance of coming adrift. Lucas CH5E, and similar dynamos with internal screws securing the bearing plate, must have these screws securely locked.

Brush Wear and Spring Tension

Brushes deteriorate more from burning than from friction. Main-brush spring tension should be 24–28 oz., and that of field brushes 14–16 oz., measured with a spring-balance. Proper bedding of brushes is essential to efficient working. A special pumice-stick can be bought for the purpose, and this is applied by holding in contact with commutator, the pumice powder bedding the brushes quickly without effecting contact. If new brushes of correct replacement type are used, they should not be tight in holders. If so, the holders may be distorted or bent and this should be corrected.

The brushes should not be rubbed down, as they are then non-standard.

Third-brush Adjustment

As a general rule, the field brush is of the same polarity as the mains' brush to which it is nearest in two-pole dynamos, and the same polarity as the mains' brush to which it is most nearly opposite in four-pole machines. Movement towards this mains' brush or position is usually in direction of rotation, and increases average output. Adjustment should be made only when the operator is certain that field-brush position is incorrect. Moving the brush forward to compensate for loss of output due to dirty or worn commutator or brushes, faulty battery, wiring, or other extraneous cause soon results in breakdown. Output should be adjusted on vehicle with headlamps of normal wattage (not exceeding 36 watts at 12 volts or 24 watts at 6 volts), when charging rate should balance discharge with a margin of 3–4 amps. For 12-volt sets, 8–10 amps. is sufficient in most cases.

Regulator Adjustments

Lucas LR-type regulators should be checked in place by opening battery circuit—inserting insulation between cut-out contacts will serve, connecting an accurate voltmeter of CVC type between *D* and *E* terminals,

and noting controlled voltage. Dual-contact "barrel" regulators should control voltage up to 15·75 volts minimum, 16·3 volts maximum, over a wide speed range. Single-contact open-type units should be set to regulate at the same values, except temperature-compensating types where voltage is up to 17 volts when cold. C.A.V.-Bosch. F- and G-type regulators should be tested only under load—not with battery circuit open. To test without battery a load of 60 watts should be applied, when regulated voltage should remain steady at 13·8 volts. Motor-cycle regulators—type MCR—should be tested on open circuit and should operate at 7·5–7·8 volts.

Adjusting Barrel Type

The field contacts should not be disturbed under any circumstances. Need of adjustment is largely due to weakening of spring, which is reset, and shortening contacts afterwards corrected to restore normal voltage control. If this does not rectify trouble the unit has burnt or pitted contact faces and should be replaced.

Adjusting Open Type

The screw with locknut situated in the back of the regulator frame alters the spring pressure on contacts. Adjustment is critical, and should be made a quarter turn, or less, at a time. The nut should be tightened each time and voltage checked. With LRT units, note temperature under bonnet. Approximate settings are: 17 volts at 50°, 16·9 volts at 60°, 16·8 volts at 70°.

Checking Circuit

If regulator voltage is correct, the dynamo should be inspected for bad commutation, belt slip, or damaged wiring. Burnt-out regulator may result if dynamo *D* and *F* leads are crossed. This should be carefully verified in all cases.

When a dynamo has been run on the test bench it should be polarised correctly before refitting on the car, so that it builds up with positive to carcase, where this is the arrangement on the car. Nine times out of ten, reversed dynamo will correct itself when cut-out closes. The tenth time it may cause a short or burnt-out warning lamp.

DELCO-REMY STARTING-MOTORS

DELCO-REMY starting-motors are of the four- or six-pole series-wound types, the four-pole type being the commonly used design. Some of the four-pole starters have field windings on only two poles, thus giving a four-pole-field action without the use of additional field-coil windings.

Some starter-motor armatures are connected to the pinion shaft by means of reduction gears, while other motors have armature and pinion on the same shaft (*see* Figs. 1 and 2).

Engagment and disengagement of the pinion with the flywheel on all starters is controlled by one of three types of drives, namely, Bendix, overrunning clutch, or Dyer drive.

Starter-motor controls, or the method of engaging the pinion on the motor with the flywheel on the engine and the closing of the motor circuit, may be divided into three types and modifications of each, as follows: (1) manual switch, (2) solenoid switch, and (3) magnetic switch.

STARTER DRIVES

Bendix Drive

A description of operation of this drive is given on page 313, and it is not necessary to repeat this here.

Overrunning-clutch Drive

Many Delco-Remy manual- and solenoid-type starter-motors use the overrunning-clutch type of drive (*see* Fig. 2). In starting, a shift lever, manual- or solenoid-operated, moves the clutch assembly on the spline shaft, shifting the pinion into mesh with the flywheel teeth. As the shift lever reaches its limit of travel, it closes the cranking motor switch contacts. Occasionally, instead of meshing, the pinion teeth and flywheel-teeth butt. When this happens, the clutch spring compresses, spring loading the pinion against the flywheel teeth. After the closing of the switch contacts takes place, the cranking motor armature need turn only one-half the width of a tooth before the pinion drops into mesh with the flywheel teeth, and cranking takes place.

After the engine begins to operate, and before the pinion can be withdrawn from the flywheel teeth, the overrunning clutch permits the pinion to overrun the motor armature, thus preventing the armature from being driven at excessive speed. The pinion is withdrawn from the flywheel teeth by the shift-lever return-spring action, after the shift lever has been released.

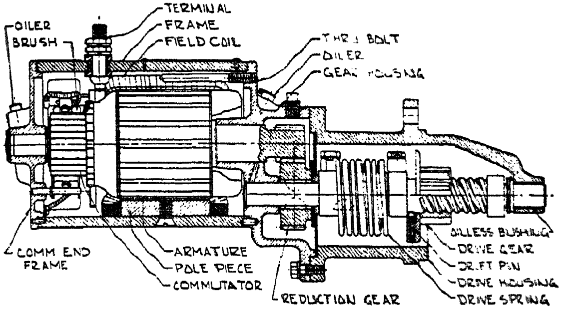


Fig. 1 (*Left*).—STARTER-MOTOR CONNECTED TO PINION SHAFT BY MEANS OF GEARS

Bendix drive.

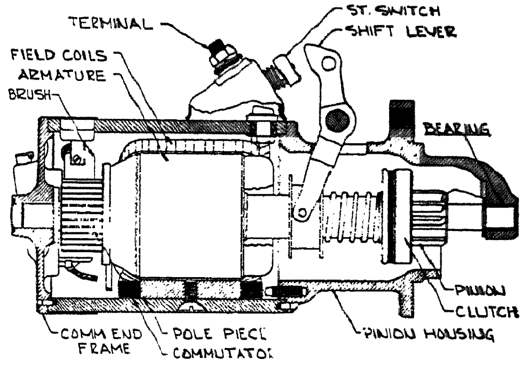


Fig. 2 (*Right*).—STARTER-MOTOR WITH ARMATURE AND PINION ON THE SAME SHAFT

The drive on the self-starter shown is of the over-running-clutch type.

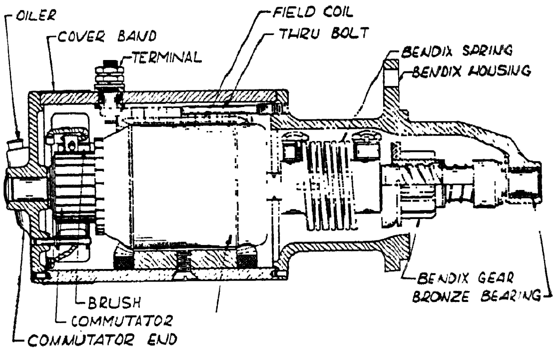


Fig. 3 (*Left*).—STARTER-MOTOR WITH ARMATURE AND PINION ON THE SAME SHAFT

The type of drive shown here is a Bendix.

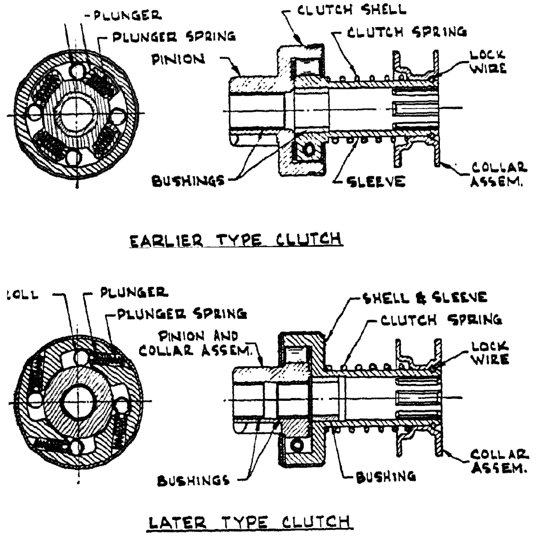


Fig. 4.—Two designs of the overrunning clutch
The later type clutch is designed so that a minimum of mass is subject to overrunning.

Fig. 4 illustrates two designs of the overrunning clutch. The later type is designed so that a minimum of mass is subject to overrunning. The heavy outer shell, formerly integral with the pinion, is integral in the later design, with the sleeve and collar assembly, which is splined with the armature shaft. The overrunning effect is more positive in the later type, since centrifugal action throws the rollers away from the overrunning section instead of toward it, as in the earlier type. This makes for less noise during the overrunning period, and lessens the possibility of clutch seizure due to excessive overrunning, with its consequent danger of thrown armature windings.

Dyer Drive

The Dyer drive (Fig. 5), used on heavy-duty petrol and Diesel-engine applications, provides positive engagement of the pinion and flywheel teeth before the cranking operation begins. The pinion is moved toward the flywheel by a manually or solenoid-operated shift lever, as in the overrunning-clutch drive. However, the Dyer drive causes the pinion to rotate as it moves toward the flywheel, so that it will find mesh with the flywheel before the shift lever completes its travel and closes the starting

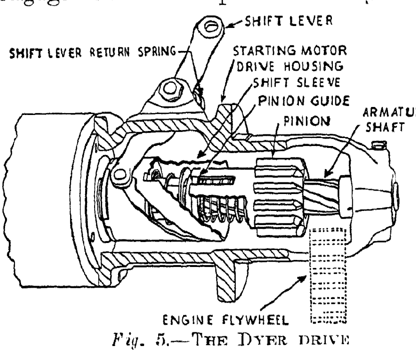


Fig. 5.—The Dyer drive

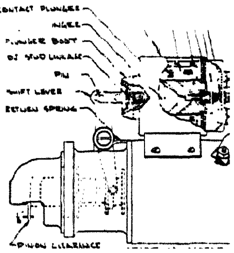
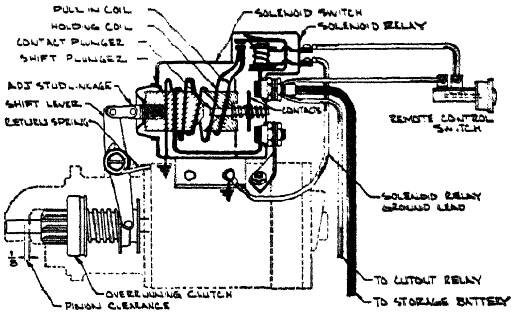


Fig. 6 (*Left*).—PUSH-BUTTON TYPE OF SOLENOID-SWITCH CONTROL

The control press-switch is situated on the dash board. Pressure on this completes circuit through solenoid on starting-motor.

Fig. 7 (*Right*).—SOLENOID RELAY AND PUSH-BUTTON CONTROL

On some cars having the control push-button on the instrument panel, the push-button is connected electrically through the ignition switch and the solenoid relay circuit is earthed through the generator main brushes or through the upper contacts on the cut-out relay. (Refer to Fig. 8.)



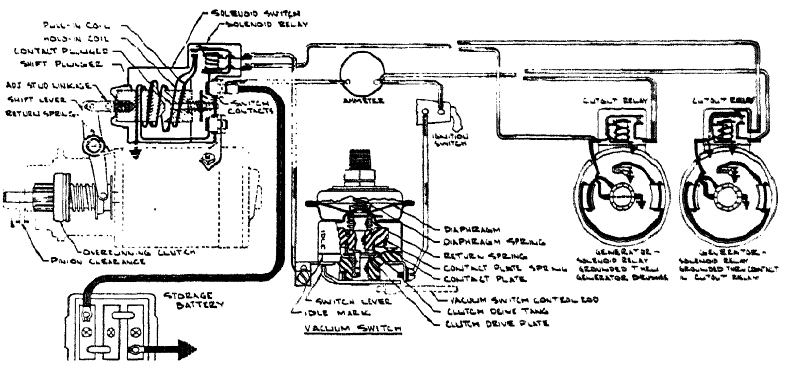


Fig. 8.—VACUUM SWITCH AND SOLENOID RELAY S1

Showing motor-control circuit through vacuum switch contacts and either auxiliary contacts in cut-out or generator brushes.

switch. When the engine fires, the pinion is spun out of mesh with the flywheel in a manner somewhat similar to the Bendix type of drive. This demeshing takes place regardless of the shift-lever position, and provides an automatic protection for the motor against excessive speed, which would result if there was meshing after the engine was running.

STARTER-MOTOR CONTROLS

Manual-switch Types

The overrunning clutch or Dyer drive, manually operated, involves the use of a foot pedal linked with the shift lever which shifts the pinion into mesh and closes the starter-motor switch contacts. The foot pedal is usually linked to the throttle, so that the throttle is partly opened when the engine is turned.

The Bendix drive does not require a shift lever. When one foot pedal is used for both starter control and accelerator, a vacuum-actuated latch device holds the starter-motor control mechanism out of the accelerator linkage when the engine is in operation.

Solenoid-switch Types

The solenoid-switch type of starter motors are controlled by :

(1) Push-button on dash (Fig. 6).

(2) Solenoid relay and dash push-button (Fig. 7).

(3) Vacuum switch and solenoid relay (Figs. 8 and 9).

The solenoid switch is used with either the overrunning clutch or Dyer-drive type of starter motor, and its function is to magnetically shift the pinion into mesh and close the starter contacts. To accomplish this action, a shift plunger linked to the shift lever (Fig. 7) is drawn into the solenoid when the solenoid windings are energised. There are two windings in the solenoid : a pull-in winding which is shorted out as the motor contacts close, and a hold-in winding which holds the plunger in the solenoid as long as the motor-control circuit is not broken. The shift-lever return-spring action opens the motor circuit and takes the pinion out of mesh when the control circuit is opened.

Dash Push-button Control

The solenoid switch may be controlled by a push-button (Fig. 6).

Dash Push-button and Solenoid Relay

On some applications a relay, solenoid or separately mounted, is used with the solenoid switch (Fig. 7). Closing the dash push-button energises the relay, causing it to close its points. Closing of the relay points completes the solenoid circuit, causing it to operate as described above.

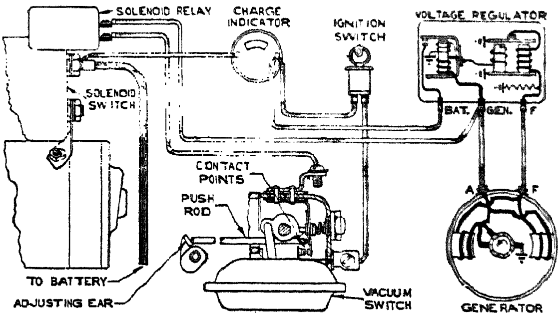
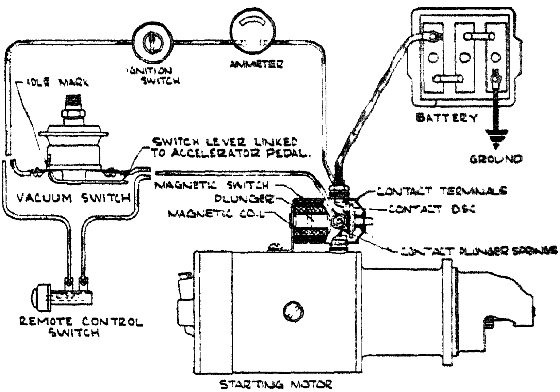


Fig. 9 (*Left*).—VACUUM SWITCH AND SOLENOID-RELAY CONTROL

In the case of a split or shunt field-type dynamo, the motor-control circuit is completed through the vacuum switch contacts, dynamo field, and regulator con-



10 (*Right.*)—MAG-SWITCH CONTROLLED BY SWITCH

Depression of the accelerator pedal completes circuit through the vacuum switch, and, as the engine fires, the vacuum created operates the vacuum switch, opening the circuit.

Solenoid Relay and Vacuum Switch

Solenoid-relay control of the starter motor in many applications makes use of a vacuum switch. In addition to making the starting operation automatic, the vacuum control protects the motor from unintentional or accidental operation which might damage the motor or drive. The vacuum switch operates on manifold and throttle opening. The opening of the throttle causes, through linkage, the vaccum-switch contacts to close. The motor-control circuit is completed through those contacts and auxiliary contacts in the cut-out relay or generator brushes (Fig. 8), or through the generator field and regulator contacts in the split or shunt field-type generator (Fig. 9). When the engine starts, the intake manifold vacuum which develops opens the vacuum-switch points. The control circuit is also opened at the cut-out relay, where the application has cut-out relay auxiliary points.

The types which complete the circuit through the dynamo brushes or field depend partly upon the counter-voltage of the dynamo acting back

through the solenoid relay to reduce the solenoid relay voltage, opening its points before the vacuum switch operates. This causes a more rapid demeshing of the motor pinion as the engine begins to operate, and is thus an added protection for the starter motor.

In the event that trouble is experienced in the starter-motor operation, it may be necessary to check all of the various units in the control circuit to be sure that they are functioning normally. Clashing of the pinion with the flywheel teeth upon acceleration may be an indication of a defective or improperly adjusted vacuum switch. Failure of the motor to operate at all might indicate an open control circuit, or it might possibly be a defect in the motor itself. Test the various units of the control circuit with a voltmeter to determine whether or not battery voltage is being delivered to the units in the proper manner.

Magnetic Switches

The magnetic switches are used with the Bendix-type starting-motors and are controlled by push-button (remote control) or a vacuum switch (Fig. 10).

With the remote-control type of switch, the magnetic coil is energised when the electrical circuit is completed through the remote-control switch on the instrument panel. After the magnetic coil is energised, the contact disc is drawn against the contact terminals and the battery current flows through the magnetic-switch terminals to the starter motor, thereby cranking the engine.

On those applications, using the vacuum in combination with the magnetic switch, the vacuum-switch lever is linked to the accelerator pedal. Depression of the accelerator pedal completes the circuit through the vacuum switch, and, as the engine fires, the vacuum created operates the vaccum switch, opening the circuit immediately, making the motor inoperative until the engine stops again.

Maintenance

In order that normal service be obtained from the starting-motor with a minimum of trouble, a regular inspection and maintenance procedure should be followed. Periodic lubrication, and inspection of the brushes and commutator as outlined here, will ensure normal operation and life to all parts. The disassembly of the motor at stated intervals for a thorough overhaul is recommended as a safeguard against road failure from accumulations of dust and grease and normal wear of parts. The battery and external circuit must be kept in good condition. Defective cables, loose or corroded connections, and defective switch contacts must be checked for and eliminated when found. Any of these conditions will result in poor starting-motor performance.

All bearings provided with hinge-cap or ball-type oilers should have eight to ten dops of light engine oil every 5,000 miles. Grey iron or bronze

bearings with grease-cups should have the grease-cups kept filled with medium cup grease and turned down one turn every 5,000 miles. Ball bearings with grease-cups should have the grease-cups kept filled with ball-bearing grease and turned down one turn every 5,000 miles. Oil plugs should be removed every six months, and the reservoir packed with graphite grease. Do not lubricate excessively, and never oil the commutator. On some models oil wicks are used for lubrication of the centre or drive end bearing. The wick is saturated with oil before assembly. Whenever the motor is removed from the engine, the oil wick should be saturated with oil before the unit is reinstalled. All oilless-type bushings should be supplied with a few drops of light engine oil. Never lubricate the motor drives, since oil tends to gum on the parts of the drive and may prevent proper action.

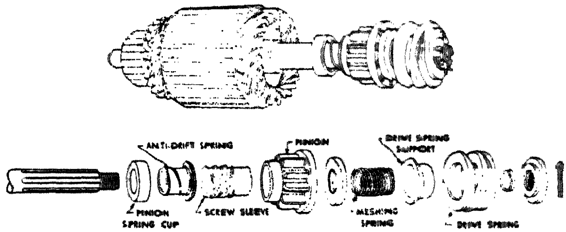


Fig. 11.—SPECIAL INBOARD-TYPE BENDIX DRIVE

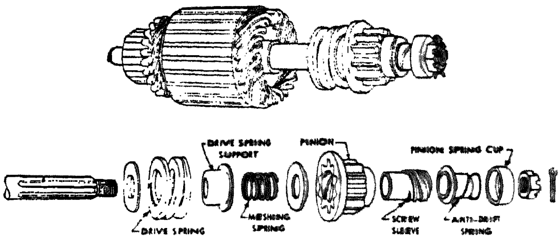


Fig. 12.—SPECIAL OUTBOARD-TYPE BENDIX DRIVE

Unless arranged in their correct order on the shaft, proper performance will not be obtained with both types of drive in Figs. 11 and 12.

Inspection

The cover band should be removed and the commutator and brushes inspected at regular intervals. Generally speaking, car starters should be inspected every 5,000 miles of operation.

If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper. Never use emery cloth to clean commutator. All dust must be blown from the motor after the commutator has been cleaned. If the commutator is rough or out of round, or has high mica, remove the unit from the engine and disassemble the armature. Turn the commutator down in a lathe, removing only sufficient material to true up the commutator and remove roughness and high mica.

Replace worn brushes. If brushes wear rapidly, check for excessive spring tension and roughness or high mica on the commutator.

Overhauling

At intervals of approximately 25,000 miles, or about once a year, the motor should be removed from the engine and completely dismantled. All parts should be cleaned and worn parts replaced.

Check the brush holders to make sure they are free on their pivot pins. The commutator should be trued in a lathe. All connections should be carefully checked and resoldered if necessary. Use resin flux in making soldered connections. Never use an acid flux on electrical connections. Submit the reassembled unit to a no-load and a torque test.

Overhauling Bendix Drive

Bendix drive should be well cleaned, but do not lubricate, since this would tend to gum on the spiral and prevent proper action. If the pinion teeth are badly burred, replace the pinion. Check the drift-pin spring, since the pinion would tend to drift into mesh while the engine is running if this spring is weakened.

Illustrated in Figs. 11 and 12 are two special types of drives, different in construction from the standard Bendix in that the complete drives are built up from separate parts assembled directly on the armature shaft. Unless arranged in their correct order on the shaft, proper performance will not be obtained. The illustrations show completely assembled drives, together with exploded views of the parts in their proper arrangement and correct order of assembly. Fig. 11 illustrates the "inboard" type, designed to engage the flywheel as the pinion moves inward or toward the armature.

Fig. 12 illustrates the "outboard" type, designed to engage the flywheel as the pinion moves outward or away from the armature.

The Overrunning-clutch Drive

The internal mechanism of this drive is packed in a special high-melting-point grease in initial assembly, and requires no further lubrication. It is not advisable to subject the overrunning clutch to grease-dissolving or high-temperature cleaning methods, since this may cause the clutch to lose its lubricant. If the pinion does not turn freely in the clutch in the overrunning direction, or the clutch tends to slip in the opposite direction, replace the assembly. A worn clutch, indicated by excessive looseness of the pinion, requires replacement. Never attempt to relubricate or repair a defective clutch.

Where the overrunning-clutch shift is solenoid-operated, as illustrated in Fig. 7, the clearance between the pinion and housing should be $\frac{1}{8}$ in. when the pinion is in the operating position. After reassembly of the starter motor, check this clearance by using battery current to hold the plunger in the bottom position. Disconnect the solenoid to starting-motor lead so that motor will not operate. Close the solenoid circuit and

push the plunger in by hand. Battery current will hold the plunger in while the pinion clearance is checked. Adjustment can be made by backing out or turning in the stud in the plunger which is linked to the shift lever.

Use a new rubber boot, as the old boot may be deteriorated enough to allow moisture and dirt to enter the solenoid.

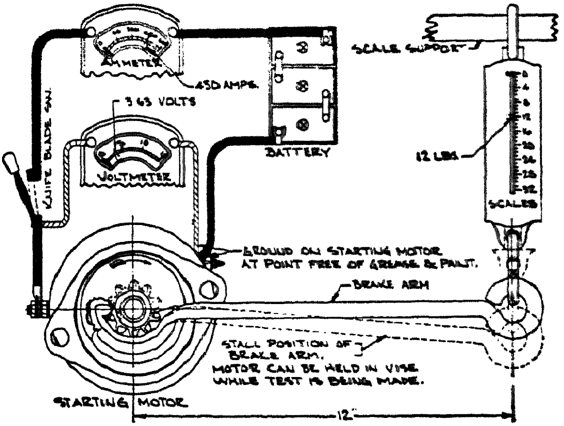


Fig. 13.—TORQUE-TEST EQUIPMENT

The throttle cracker linkage to the starting-motor shift lever should be adjusted in accordance with the car manufacturer's instructions. Care should be taken to avoid an excessively wide throttle opening during initial start, since this will put undue stress on the overrunning clutch.

Checks on Improperly Operating Starting-motor

If the motor turns the engine slowly or not at all, check the battery, battery terminals and connections, the earth cable, and the battery-to-motor cable. Corroded, frayed, or broken cables should be replaced, and loose or dirty connections corrected. The motor switch should be checked for burned contacts, and the switch or contacts replaced as necessary.

If all these are in order, remove the cover band of the motor and inspect the brushes and commutator. The brushes should form good contact with the correct brush-spring tension. A dirty commutator can be cleaned with a strip of No. 00 sandpaper held against the commutator with a stick, while the starting-motor operates with the ignition switch off. If the commutator is very dirty, or burned, or has high mica, remove the starting-motor, disassemble the armature, and take a cut off the commutator in a lathe.

If there are burned bars on the commutator, it may indicate open-circuited armature coils which will prevent proper cranking. Inspect the soldered connections at the commutator riser bars. An open circuit will show excessive arcing at the commutator bar which is open, on the no-load test.

Tight or dirty bearings will reduce armature speed or prevent the armature from turning. A worn bearing, bent shaft, or loose field-pole

screws will allow the armature to drag on the pole shoes, causing slow speed or failure of the armature to revolve. Check for these conditions.

If the brushes, brush-spring tension, and commutator appear in good condition, the battery and external circuit found satisfactory, and the starting-motor still does not operate correctly, it will be necessary to remove the starting-motor for no-load and torque checks.

No-load Test

Connect the starting-motor in series with a battery of the specified voltage and an ammeter capable of reading several hundred ampères. If an r.p.m. indicator is available, read the armature r.p.m. in addition to the current draw.

Torque Test

Torque-test equipment such as illustrated in Fig. 13 is required to determine if the motor will develop its rated torque. The motor is securely clamped in position and the brake arm hooked to the drive pinion. If the brake arm is 1 ft. long, the torque, when the circuit to the starting-motor is closed, may be read directly from the scale. Some types of torque testers indicate the reading directly on a dial. It is advisable to use in the circuit a high current carrying variable resistance, so that the specified voltage at the motor can be obtained. A small variation of the voltage will produce a marked difference in the torque developed.

Interpreting Results of No-load and Torque Tests

(1) Rated torque, current draw, and no-load speed indicates normal condition of starting-motor.

(2) Low free speed and high-current draw with low developed torque may result from :

(*a*) Tight, dirty, or worn bearings, bent armature shaft, or loose field-pole screws, which would allow the armature to drag.

(*b*) Shorted armature. Check armature further on growler.

(*c*) An earthed armature or field. Check by raising the ground brushes and insulating them from the commutator with cardboard, and then checking with a test lamp between the insulated terminal and the frame. If tests lamp lights, raise other brushes from commutator and check fields and commutator separately to determine whether it is the fields or armature that are earthed.

(3) Failure to operate with high-current draw :

(*a*) A direct earth in the switch, terminal, or fields.

(*b*) Frozen shaft bearings, which prevent the armature from turning.

(4) Failure to operate with no-current draw :

(*a*) Open field circuit. Inspect internal connections and trace circuit with a test lamp.

(*b*) Open armature coils. Inspect the commutator for badly burned bars. Running free speed, an open armature will show excessive arcing at the commutator bar which is open.

(*c*) Broken or weakened brush springs, worn brushes, high mica on the commutator, or other causes which would prevent good contact between the brushes and commutator. Any of these conditions will cause burned commutator bars.

(5) Low no-load speed, with low torque and low-current draw, indicates :

(*a*) An open field winding. Raise and insulate ungrounded brushes from commutator and check fields with test lamp.

(*b*) High internal resistance due to poor connections, defective leads, dirty commutator, and causes listed under (4) (*c*) above.

(6) High free speed, with low developed torque and high-current draw, indicates shorted fields. There is no easy way to detect shorted fields, since the field resistance is already low. If shorted fields are suspected, replace the fields and check for improvement in performance.

TESTING AND ADJUSTING VACUUM SWITCH FOR STARTER-CONTROL CIRCUIT

Two types of vacuum switches are used, one being mounted on the intake manifold, while the other is mounted on the carburettor control or carburettor.

Manifold-mounted Vacuum Switch

The vacuum switch illustrated in Fig. 14 mounts on the intake manifold and is directly connected to the throttle linkage. The switch lever has a pointer, which, used with the white mark on the switch rim, provides an easy way to adjust the vacuum-switch linkage. With the engine idling, adjust the pointer to the white mark. Refer to car manufacturer's detailed instructions covering such adjustments pertaining to the engine.

Where other safety devices are used in conjunction with the vacuum switch to protect the starting-motor, the vacuum switch may become defective without impairing the starting-motor operation. For this reason the vacuum switch should be checked occasionally, as follows :

(1) With the engine idling, disconnect the two leads on the vacuum switch.

(2) Connect a 110-volt test lamp on the two terminals.

(3) Open the throttle to increase engine speed. (No light should occur from idle to high speed.)

(4) With the engine still idling, disconnect the throttle lever from switch and move the switch through the complete range of travel. (Lamp should not light or no binding should occur through the total range.)

(5) With the lever in the centre position, disconnect the vacuum line. Move the lever to full-throttle position and return to within $\frac{1}{8}$ in. of idle

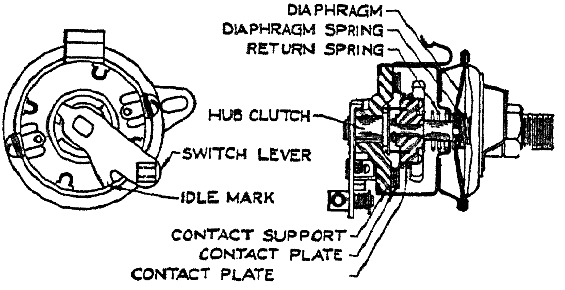


Fig. 14.—MANIFOLD MOUNTED VACUUM SWITCH

position or white line on the switch case. At this position, $\frac{1}{8}$ in. ahead of white line, the contact assembly will be released, giving a clicking noise. (Test lamp should not light at any time.)

(6) After contact assembly has been released, movement of the switch lever forward through $\frac{1}{16}$ in. to $\frac{1}{8}$ in. of travel should complete the circuit through the switch. The test lamp should light.

Carburettor or Carburettor Choke-control Mounted Vacuum Switch

On this type of switch, illustrated in Figs. 15 and 16, mechanical linkage is obtained through the carburettor throttle shaft, and the " adjusting ear " and " push-rod " in the switch.

As the carburettor throttle valve is opened and closed, motion from the throttle is transmitted through the adjusting ear to the push-rod, to open or close the contact points of the vacuum switch.

Engine not Running

When the engine is not running (Fig. 16), the carburettor throttle is held in the closed position by the throttle-return spring, and the adjusting ear against the push-rod holds the contact points open. The vacuum diaphragm is in the " at rest " position, as there is no vacuum in the intake manifold.

Starting Position

In starting the engine after the ignition switch has been turned on (Fig. 17), closing of the vacuum-switch contact points will complete the motor-control circuit and cause the solenoid to mesh the motor-drive pinion and close the starter switch.

Depressing the accelerator opens the throttle valve and allows the adjusting ear and push-rod to move as shown in Fig. 17. A 40°–50° throttle opening allows the contact points to close, completing the cranking-motor control circuit. *Note.*—When operating the choke-control unit by hand always turn the shaft clockwise (viewing carburettor side of choke assembly) as too much movement in opposite direction may damage contact spring.

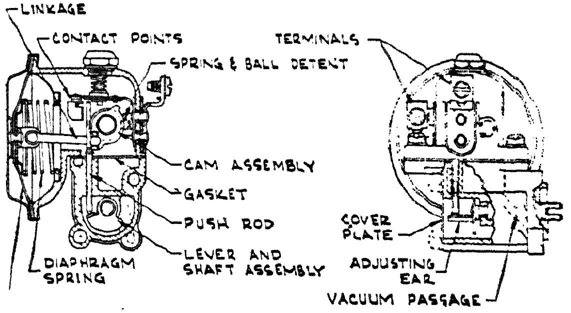


Fig. 15.—CARBURETTOR CONTROL MOUNTED VACUUM SWITCH

This switch is identical in operation to the vacuum switch shown in Fig. 11, which is mounted on the carburettor choke control. Both obtain linkage to the carburettor throttle shaft through a mating sub-shaft, adjusting ear, and push-rod.

Engine Running

As soon as the engine starts to run (Fig. 18), the intake manifold and vacuum chamber of the vacuum switch are evacuated through the vacuum passage shown in Figs. 15 and 16.

The vacuum diaphragm collapses, compressing the switch spring and rotating the switch cam. The lug on the switch cam opens the contact points and latches on an insulated pin on the contact-point blade, holding the points open. A spring and ball detent mechanism (not shown in the diagram) gives a wide differential between the vacuum required to open the points and the vacuum required to hold them open. It takes a vacuum of 5 in. hg. to open the points, but when once open they will not close until this vacuum has dropped to below ½ in. hg. This is important, as it guards against possible engaging of the motor pinion when the vacuum is very low, as it would be when accelerating under load.

Engine Stopped

When the engine is stopped, the vacuum diaphragm attempts to return to its "at rest" position, but the lug on the switch cam, latched by the pin on the contact blade, holds the contacts open until the throttle closes. When the throttle

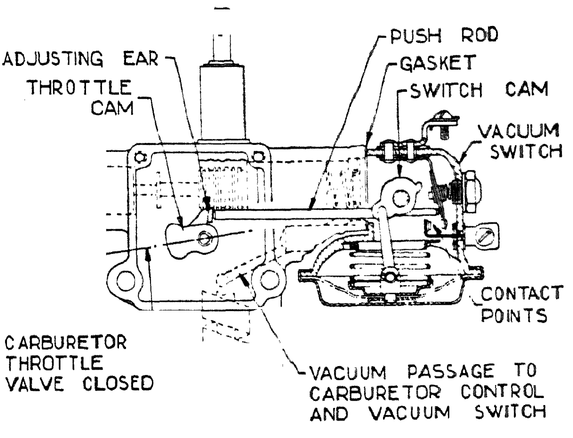


Fig. 16.—VACUUM SWITCH MOUNTED ON CARBURETTOR CONTROL—ENGINE NOT RUNNING

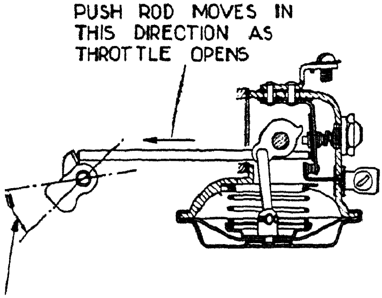


Fig. 17.—OPERATION OF VACUUM SWITCH
Engine being cranked.

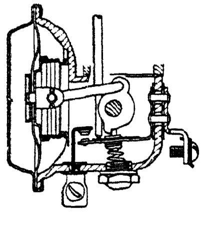


Fig. 18.—OPERATION OF VACUUM SWITCH
Engine running (contact points held open by latched cam).

closes, the adjusting ear moves the push-rod towards the contact arm, opening the points sufficiently so that the cam unlatches, allowing the vacuum diaphragm to return to the " at rest " position. The contact points are held open by the push-rod, but are free to close when the throttle is opened and the push-rod moved away from the contact arm.

Method of Testing on Engine

The setting at which the switch cam unlatches to allow the contact points to close again after the engine has been stopped is an important factor in the correct operation of the starting system.

Note.—Switches are adjusted at the factory to unlatch at a fairly " fast " throttle position (23°–26° throttle opening on the choke-mounted type, and 25°–28° on the carburettor-mounted type) to allow for the stiffness of new engines. If, after the engine has worn in, there is a tendency for the pinion to clash upon acceleration, the adjusting ear on the throttle cam can be bent back so that the unlatching point will occur at 22°–24° throttle opening. The unlatching point of the switch can be checked on the engine as follows :

(*a*) Set idle screw for 8 m.p.h., hot idle, then stop engine.

(*b*) Pull out hand throttle until distance between end of idle screw and cold-idle cam in fast-idle position is $\frac{1}{16}$ in. This can be set with $\frac{1}{16}$ in. spacer. Hand throttle must be left in this position throughout following test.

(*c*) Turn on ignition and start engine.

(*d*) Turn off ignition and make another start immediately after engine is stopped. This starting operation should be repeated at least three or four times. If the engine starts in each case after making the above check, the vacuum switch is timed properly for making contact in all positions of cold-idle cam.

(*e*) Pull out hand throttle until space between idle-adjustment screw and cold-idle cam in fast position is ¼ in. It should be impossible to start the engine more than once with the throttle in this position.

If starting is possible under the conditions in (*e*) or is not possible under the conditions in (*b*), (*d*), the unlatch point is not in proper adjustment, and the carburettor and control unit should be removed from the engine and further tests and adjustments made on a vacuum tester. The carburettor-mounted switch (Fig. 10) has an opening through which the adjusting ear may be reached without removing the switch from the engine. Loosen the two through-bolts and swing the protective cover out of the way to get to adjusting ear. Tighten bolts before checking and adjusting. Bending the ear away from the push-rod lowers the contact-point unlatching setting.

When assembling switch unit to choke, on the choke-mounted type, be sure to open the throttle to wide-open position and push the push-rod in against the shoulder. This will ensure against possible damage to the switch-contact arm.

As long as the choke and switch assembly functions satisfactorily, do not change any adjustments even though the unlatch point does not fall within the limits specified above.

PETROL-CONSUMPTION TESTS

By C. R. B. SMITH

THE main essential in investigating high petrol consumption on any vehicle is the correct diagnosis of the exact position of the throttle at which excessive richness is taking place.

Finding Position of Throttle at which Excessive Richness Occurs

This can invariably be located by running the engine up light, and listening to the exhaust note. Heavy, lumpy running, invariably with black smoke from the exhaust, indicates an over-richness in the mixture.

The amount of opening of the throttle valve during this test will then give a line as to whether the richness lies over the whole of the throttle range or is located at the pilot end, the intermediate jet stages, or purely main jet at the large throttle openings.

Richness at all Throttle Openings

In the event of the richness being apparent at all throttle openings on a car which has originally been correctly carburated, this will invariably be found to be due to either a punctured float, worn needle or needle seating, or, finally, a pressure being set up—in the case of a mechanical fuel pump —which is in excess of that which the needle seating of the float chamber is capable of withstanding.

In the event of either or both of the first two faults mentioned being the case, rectification is, of course, the fitting of new parts.

Trouble due to High Fuel-pump Pressure

In the case of the trouble being due to high mechanical fuel-pump pressure, a definite alteration to the diameter of the needle seating itself will be necessary. To enable this trouble to be completely cured a reliable pressure gauge should be introduced into the fuel line between the pump and the carburettor, and the exact pressure recorded on it should be noted. A suitable seating for the float chamber can then be supplied by the carburettor manufacturers to successfully withstand the pressure in question.

Faulty Adjustment of Pilot Air Screw

A great source of petrol wastage on the average car to-day lies with a faultily adjusted pilot air screw. On most present-day carburettors, this controls the amount of air going to the slow-running assembly, and if set

on the rich side results in a very marked increase in petrol consumption, due to the fact that this slow-running system is subject to a very high depression on every overrun, with the result that when this adjustment is set at all on the rich side, an over-rich mixture is being continually drawn into the motor, and, in town work particularly, will lead to excessive wastage. Consequently, this adjustment should always be set, when consumption is being studied, as weak as possible consistent with decent slow-running; if the engine tends to race when this screw is adjusted on the weak side, then the engine r.p.m. should be slowed down by means of the adjustable throttle stop-screw.

This is *very important*, as quite a common habit is to slow down the speed of the engine tick-over by richening the pilot air-adjusting screw, instead of utilising the throttle stop-screw as mentioned previously.

"Banging" in the Silencer on Overrun

A point well worth bearing in mind during the original diagnosis as to mixture strength is the well-known symptom of "banging" in the silencer on the overrun. This can be caused by faulty pilot adjustment, which, of course, can be readily checked up by alternately richening and weakening the pilot adjusting screw and checking the car on the overrun. One of the main causes of this symptom, however, is a bad air leak in the silencer system, either in the silencer itself or at one of the exhaust flanges. This results in a certain amount of richness, which must take place from the pilot system on the overrun, passing through into the warm silencer, and the amount of air which it picks up from the air leak on its way makes it so readily combustible that the heat of the silencer ignites it, with a second small explosion, which is alluded to as "banging" in the silencer. This point should always be well checked up before any alteration to carburettor setting is made.

Mistaken Use of Small Jets

A great fallacy, which seems to be much believed, is that a good petrol consumption can be obtained by the usage of small jets in the carburettor. This is quite a mistake, as, invariably, the usage of a very "thin" mixture setting will not give as good all-round petrol consumption as a correct setting, due to the fact that for a given speed the throttle has to be opened very much more on the very thin setting than it would be on the correct mixture, with an ultimate increase in depression on the jets.

Tuning up for Good Petrol Consumption

When tuning up, therefore, for consumption, the correct jet setting to give the maximum performance of the car should be fitted, with special attention paid to the slow-running adjustment, as previously mentioned, and such things as leaky washers, dripping taps, etc., fully eliminated. By this means it will be found that a really good petrol-consumption

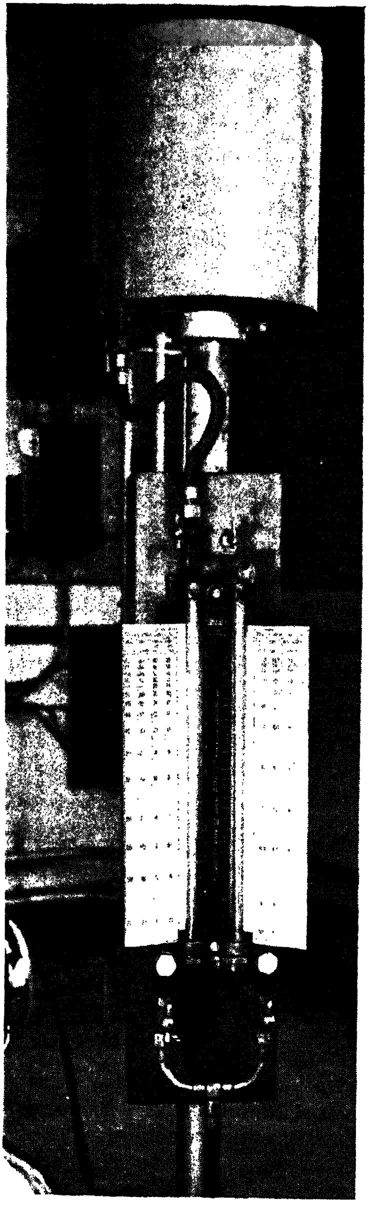


figure will be obtained without in any way detracting from the performance of the vehicle.

A Further Adjustment on Acceleration-type Carburettor

Another adjustment on the acceleration pump-type of carburettor can be achieved by altering the time period of the pump stroke. This, on most pump-type carburettors, consists of an adjustment of the stroke of the pump as well as an adjustable pump jet. It will often be found that snap acceleration, when the accelerator pedal is suddenly depressed, can be obtained quite as readily with the pump set to give quite a small stroke, instead of utilising its full stroke, with the consequent positive saving of a certain amount of fuel each time the accelerator is suddenly depressed. It will be readily appreciated that a large saving can accrue over a long run by this method.

PETROL-CONSUMPTION TESTS

Now, as regards general means of testing petrol consumption, there are really three methods of going about this:

(1) Using a flowmeter attached to a car test set.

(2) Checking the analysis of the exhaust gas, which is a direct indication of mixture strength.

(3) Road test of miles done on a known quantity of fuel.

(*Left*) AMAL FLOWMETER FOR TESTING PETROL CONSUMPTION

The flowmeter is coupled in the fuel system. Pints per hour scales are indicated in the centre. The white scales indicate the corresponding miles-per-gallon figures at various

(*By courtesy of Shaw & Kilburn, Ltd.*)

Use of a Flowmeter

With regard to the first method, this usually consists of an Amal flowmeter which is incorporated in a large test set which is equipped for showing the brake horse-power of the car being tested, as well as pints per hour being used at certain road speeds; subsidiary tackle is usually incorporated for synchronising brake adjustment, etc. The Amal flowmeter in this case is coupled in the fuel system and indicates by means of the level of petrol in a glass tube, on a scale, the pints per hour which the carburettor is taking. The float chamber on the flowmeter itself maintains a constant level in this instrument, and the fuel supply to the glass tube is controlled by a known size "venturi jet." Consequently, a balance is obtained between the venturi jet and the amount of fuel flowing to the carburettor. This results in a certain level being reached in the glass tube, which is then read off a scale-plate at the back in pints per hour.

When dealing with these instruments, great care should be exercised that all air bubbles, etc., are cleared from the machine before a run is made, otherwise an artificial level of fuel in the glass tube can be obtained, resulting in a wrong reading being taken.

Naturally, the procedure with this instrument when it is used for checking petrol consumption is to take a series of readings at various road speeds with various brake horse-power indicated and the smallest pints-per-hour reading possible being obtained on the flowmeter. It is always essential, of course, on any of these tests, to take a base reading before the carburettor is touched in any way, so that one knows exactly the value of the improvement obtained.

Exhaust-gas Analysis

Regarding the second method, of exhaust-gas analysis, a typical portable plant consists of a sampling tube clipped to the exhaust pipe of the vehicle, which leads through the instrument and records on a movable pointer the petrol-air ratio of the mixture strength. This instrument, which is quite compact in size and shape, can be carried inside the car, and a run done over a known test circuit. Petrol-air ratios can then be jotted down by an observer in conjunction with speedometer readings at certain points of the test circuit. This can then be repeated after carburettor adjustments have taken place, and their various effects can be then noted by the alteration in petrol-air ratios shown.

This method, of course, is a pure comparator, and gives only a ready indication of the alterations which have been made to the carburettor setting.

How to carry out a Petrol-consumption Test on the Road

Concerning the third and last method of petrol-consumption test, this consists in using a certain quantity of fuel over a known mileage, giving

the actual consumption of the car in question in miles per gallon. There is only one absolutely foolproof method of doing this, and that is to utilise a small test tank, which can be of any capacity, but which should have a small-diameter vertical filler neck on which a visible mark is scratched.

This tank can be put in parallel with the main fuel system of the car and the necessary three-way tap incorporated close to the driver, so that the car can be driven to a certain test circuit on its own fuel tank, and then at will switched over to the consumption-test tank at a given point.

The Test Run

The normal procedure is as follows: fill the test tank up before leaving the repair works to the mark on the narrow neck of same. It is then necessary either to work on the car speedometer, if known to be accurate, or else, better still, as previously mentioned, to use a test circuit the mileage of which is accurately known.

In the first case, the speedometer trip is set to zero, the test-tank tap is opened, and any mileage is done within the capacity of the test tank. In the case of the known mileage-test circuit, the tank is switched into operation as the first mark of the test circuit is passed, and again switched out of operation as the last mark of the test circuit is passed. In either case, therefore, a known mileage has been done, which is the essential.

Measuring the Amount of Petrol Consumed

The procedure is then as follows: By means of a fluid-ounce measure, the small test tank is then "topped up" until it is up to the mark previously mentioned on the filler neck. Having a narrow vertical neck does away with the possibility of error in the filling. The number of ounces which it is necessary to put in to fill up to the mark must be carefully noted.

Calculating Miles per Gallon

$$160 \times M = \text{miles per gallon},$$

M being the number of miles travelled, and Q quantity used in fluid ounces, the petrol consumption in miles per gallon can be determined.

This is a very much more accurate method than, say, putting a gallon of petrol in a tank and running the car until it is consumed, as it does away with the possibility of error due to fuel running out in the one case on a down-hill gradient, or in another case on an up-hill gradient, etc., which on a small quantity of fuel naturally multiplies the error immensely.

It will, therefore, be noted that the actual capacity of the test tank is of no moment, it being necessary only to accurately measure the amount of fuel put in to top up to the original mark on the neck.

The Amal Flowmeter

Reverting back to the use of an Amal flowmeter, the illustration shows this instrument, on which will be noted the pints-per-hour scales situated in the centre, and on either side white subsidiary scales which convert these readings to miles-per-gallon figures at an indicated miles-per-hour speed.

It will thus be seen that the miles per gallon can be immediately read off the instrument by referring to either the right- or left-hand scale-plate, according to which pints-per-hour tube is being used. Should at any time a discrepancy be suspected in the functioning of this flowmeter, a ready check is quite easily made. The fuel pipe from the flowmeter to the carburettor should be disconnected at the tap of the flowmeter, and this tap should be slightly opened to allow a small quantity of fuel to run out.

With the aid of a stop-watch and a certified glass measure a timed flow for one minute should be taken, which, after being converted into pints per hour, should be compared with the actual scale reading.

A set of these readings should then be taken over the whole of the scale, that is, by varying the tap opening, and unless the scale readings absolutely agree with the measured quantity, there is then some error in the machine's recording. This is invariably traced to dirt or foreign matter of some description getting into the venturi jet, which is situated at the base of the flowmeter tubes. There is a separate venturi jet for each scale, that is, two per machine. In the event of one of these jets getting slightly silted up, the machine will record a greater pints-per-hour flow than is actually taking place, due to the fact that the balance between the filling and emptying of the glass tube has been upset.

These venturi jets should be cleaned with a piece of soft twine or wool, and under no circumstances should be cleaned out by using a metal instrument, such as a needle or a reamer, as, should they in any way be enlarged, this then renders the scale readings inaccurate.

In the event of the venturi jet apparently being clean, as well as the rest of the machine, and the scale readings still not indicating the true quantity collected in the measuring glass, then the makers' assistance should be called in.

Do not alter Carburettor Petrol Levels

In conclusion, it might be as well to draw attention to the fact that under no circumstances should petrol levels of carburettors be altered in an endeavour to obtain a good petrol consumption ; invariably the level set by the makers has been found to be ideal for general purposes, and an alteration to this will most probably lead to the obtaining of an unsatisfactory setting.

THE ELECTRICAL EQUIPMENT ON THE HILLMAN MINX

DYNAMO

THE bearings supporting the dynamo armature should be lubricated sparingly at intervals of approximately six thousand miles. It is also advisable to examine the commutator and brushes periodically, and to clean the commutator if necessary.

In cleaning a commutator it is important that emery cloth should not be used. The most satisfactory method is to use one of the pumice sticks specially prepared for this purpose, but if this is not available, glasspaper will be found to be a fairly satisfactory substitute.

Pressure of Brushes

It is most important that the brushes should operate freely in their carriers, and if, as the result of continual use, the spring pressure on the brushes appears to be unsatisfactory, it can be tested as follows :

Hook a small spring balance round the loop at the end of the spring. The spring on the thin control brush should lift when a pull of 14 ozs. or more is applied, whereas the spring on the main brushes should not lift until subjected to a pull of at least 18 ozs. If the brushes have worn extensively and replacements are fitted, it is usually advisable to test the spring tensions, as they may have been overheated by use with worn brushes, and will as a result have lost their strength.

When new brushes are fitted, the bedding of these brushes to the commutator is accomplished by the use of the special pumice sticks on the commutator. The powder clings to the commutator and in the segments and satisfactorily beds the brushes to the commutator. After the commutator stick has been used, the dynamo should be left running for approximately five minutes with the brush cover removed. The remaining powder should then be blown away.

Commutator

After extensive use the segments or bars of the commutator will have worn. It then becomes necessary to cut back the mica insulator fitted between each commutator bar. This must be done with extreme care, use being made of a parallel-sided saw.

As special equipment is really necessary, it is recommended that this should only be undertaken by a fully qualified electrician possessing the

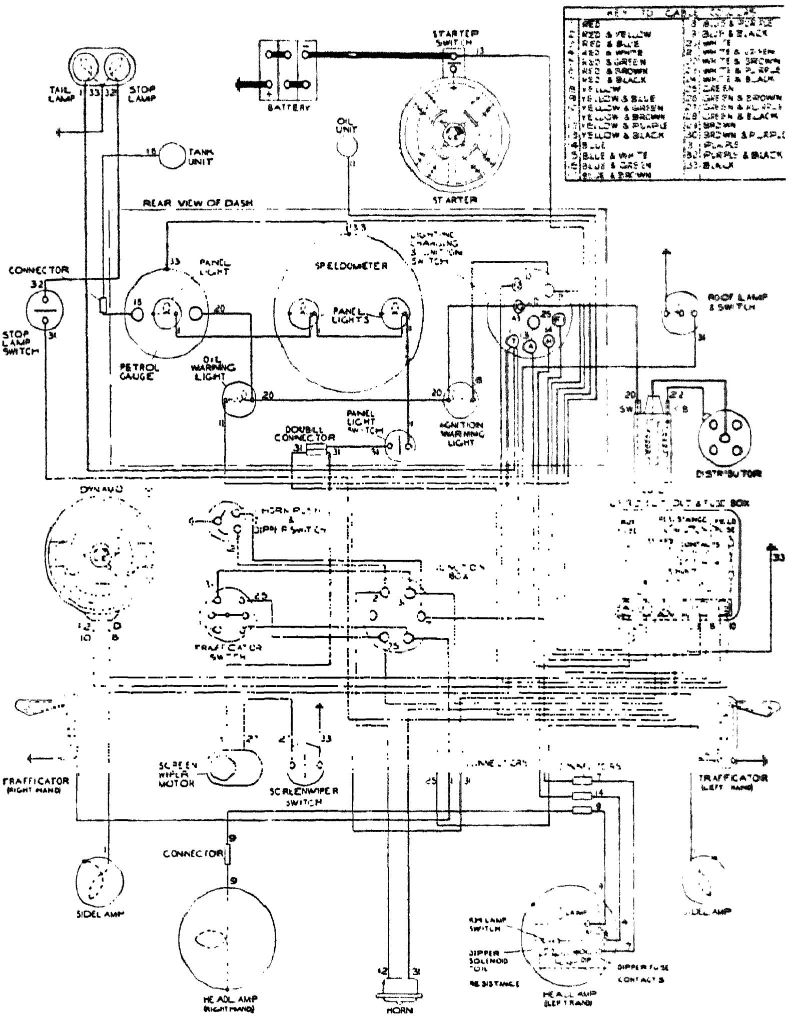
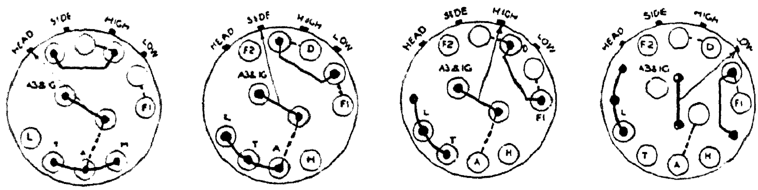


Fig. 1. WIRING DIAGRAM OF THE HILLMAN MINX (1939)



SWITCH IN "HEAD" POSITION IGN SWITCH ON. | SWITCH IN "SIDE" POSITION IGN SWITCH ON | SWITCH IN HIGH POSITION IGN SWITCH ON | SWITCH IN LOW POSITION IGN SWITCH OFF

Fig. 2.—SWITCH CONNECTIONS

equipment. To gain access to the commutator for this treatment it be necessary to dismantle the dynamo, as described later.

Control Brush

On examining the brush gear, it will be found that the thin brush is mounted so that it can be moved relative to the two fixed brushes. The original setting is marked with white paint. The dynamo is despatched from the factory so that it gives its maximum safe output. The output of the dynamo can, however, be reduced should circumstances demand it, by moving this control brush slightly in the opposite direction to that in which the armature turns.

To Dismantle Dynamo and Rebuild

Remove dynamo from engine. Remove fan pulley. Remove two bolts passing from end to end of the unit. Withdraw carefully the commutator end, and when this has been brought a short distance, disconnect the leads to the brushes. The end complete with brush gear can then be removed. The armature complete with the front end plate can also be withdrawn.

In rebuilding the unit, extreme care must be taken to lift the brushes so that they pass over the edge of the commutator, otherwise damage will be done to the brush gear.

STARTER MOTOR

The attention required by this unit is very similar to that required by the dynamo, although it will not be necessary to attend to this except at very long intervals.

In the case of the starter motor, a tendency to blacken the commutator will be noticed. This is inevitable. As the occasion arises, the commutator should be cleaned, using a commutator stick as for the dynamo.

Starter Drive

The starter engages in the flywheel through a special pinion operating on a spiral. The important point is that this pinion or its spiral should

not be lubricated in any way, and it should be examined periodically to make sure that it is clean and free from oil, as if oil and dirt are allowed to coagulate, the engagement of this pinion in the flywheel may become spasmodic.

To prevent the pinion from rolling forward and catching the flywheel a light spring is fitted in front of the sliding pinion, i.e. between the pinion and the starter motor. If any noise is heard from this part, particularly when the brakes are applied, it indicates that this spring should be replaced.

In the event of the starter motor pinion becoming jammed in the starter gear, this can be freed by removing the small cover held over the forward end of the armature spindle by two small screws. This will reveal a square shank, and it should be turned in a clockwise direction by means of a spanner.

If it is necessary to dismantle the starter pinion, the starter should be removed and the left-hand threaded nut unscrewed from the rear end of the armature spindle, when the spring, sleeve and pinion may be removed.

Lubrication

The cap held by two small screws at the forward end of the armature spindle is filled with grease during erection, and it is unlikely that it will require further attention except at very infrequent intervals.

If the starter should become noisy, particularly after the car has started, whilst the starter revolutions are dying down, it is an indication that grease is required at this point and the cap should be removed.

The rear bearing for the starter armature is packed with lubricant during erection and does not require attention.

IGNITION SYSTEM

Cleaning of Points

When the engine has been in use for some considerable period, an examination of the contact breaker points on the distributor will reveal that whilst a crater has formed in one point, a corresponding tip or point is built up on the opposite point.

To clean the distributor points and at the same time to ensure that there is no undue wastage of material, the point with the crater should not be touched. The tip formed on the other point should be lightly ground off on an oil stone.

Lubrication

Mounted at a point on the distributor body in some 1936-7 and in 1938 and 1939 models is an ordinary oiler. Thin lubricating oil should be applied here, when it will percolate through the porous bush supporting the distributor shaft and thus provide lubrication at this point. Some distributors on 1936-7 models are provided with a grease cap which should be moved two turns approximately every 1,000 miles.

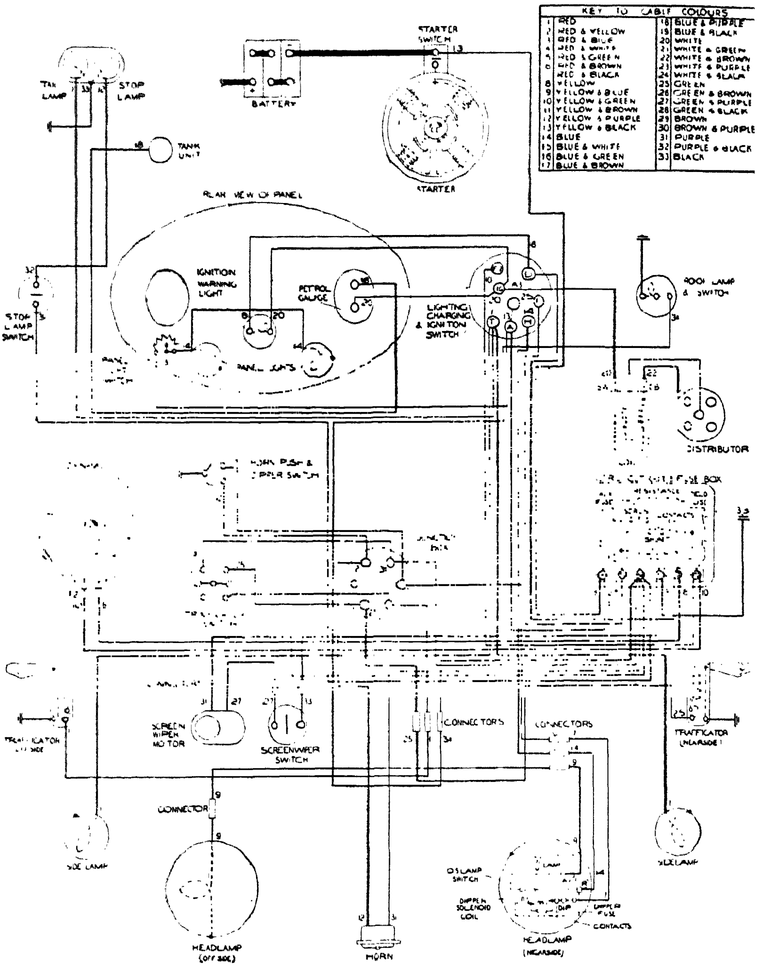


Fig. 3.—WIRING DIAGRAM OF THE HILLMAN MINX (1938)

Upon removing the distributor cap and the rotor, it will be that the cam gear is hollow and that the distributor shaft is extended through the cams. Actually the cams are advanced by the centrifugal mechanism on the distributor shaft at this point.

To prevent seizure, oil should be applied to the head of the shaft, which is capped by a setscrew and which need not be removed. This oil will pass down the bearing, keeping the cam gear free, and also provide lubricant for the pins supporting the centrifugal weights.

Suction Advance Mechanism

The centrifugal control in all Hillman Minx from Chassis No. 1005431 (1938) is supplemented by an external suction control device which is connected to a special point on the carburettor.

It is essential that the distributor should operate freely in the mounting bracket secured to the cylinder head. This point should be checked periodically, and if necessary the distributor should be removed from the mounting bracket so that the bearing between the two may be lubricated with a graphite grease.

Coil

The coil requires very little attention. It is, however, important that surface leakage between the terminals should be prevented by keeping the top of the coil quite clean. The earth return from the coil is through the battery, and thus poor battery connections will cause a misfire and ignition troubles.

Cut-out and Fuse Box

This is mounted on the dash pan and is a unit with the junction box shown on the wiring diagrams (for 1939 models, see page 371). Below the cover of the cut-out two fuse clips are provided ; the short fuse of 6 amps. capacity is in the dynamo field circuit, whilst the long fuse of 25 amps. capacity is provided for the auxiliary equipment, such as horn, windscreen wiper, trafficators, roof light, etc. Should any fitting be added, it should be connected to the terminals marked "AUX" and "E" so that this fuse is incorporated in the circuit.

Great care should be taken that the points of the cut-out are not pushed together whilst the lid of the cut-out is removed, for, say, the replacement of the fuses. As a precautionary measure any odd piece of thin card, such as a cigarette card or a tram ticket, should be placed between the cut-out points whilst the fuses are receiving attention.

To Remove and Refit Speedometer

To remove speedometer on 1939 models, disconnect speedometer cable. Remove panel switch complete with bracket by undoing the two screws securing the bracket to the speedometer. Pull panel bulbs out of

rear of speedometer. Remove knurled nuts securing clamp to speedometer and disconnect earth wire. Speedometer can then be removed through front of panel.

The replacement is a direct reversal of the above operations. *Take care to replace earthing wire* below knurled nut of clamp.

Instrument Panel and Warning Bulbs

There are four 6-8 volt (2 watts) screw-in-bulbs on the instrument panel, all of which are interchangeable except petrol gauge bulb which is special 6-8 volts (1·8 watts). The holders of the ignition and oil pressure wiring bulbs, also the lighting bulbs in the speedometer assembly, can be pulled out of their sockets. In the case of the fuel gauge, the contact plate to the lower contact of the bulb is pushed to one side when the bulb, complete with holder, can be withdrawn.

THE ELECTRICAL EQUIPMENT OF THE FIAT MODEL 500 CAR

Battery

A MARELLI 6 BA 7 or Exide 6 LHS 7-1, of 30 amp. hours capacity, is fitted in a box under the floor of the tail of the body on the left-hand side and is easily accessible for inspection.

Starting Motor

This is located on the left-hand side of the cylinder block. Engagement of the motor pinion with the flywheel crown is controlled, at the same time as the starting switch, by a pull knob on the dash. From engine No. 033508, the pinion is fitted with free-wheeling device and is driven by the starter motor spindle through two reduction gears. Prior to this serial engine no. the motor spindle drives the pinion directly. The pinion is not provided with a free-wheel device.

Lamps

These are mounted on the wings by means of a ball headed stud, allowing of easy adjustment of the light beams. The lamp for town driving is 3 watts, a central double filament 35 watt lamp is used for headlights and 20 watt lamps for anti-dazzle lights.

The dash lamp with push button switch on the instrument board is provided with a revolving shade which can be turned so as to light up either the instrument board alone or the whole of the interior of the car (3 watt lamp).

A plug-in connection for an inspection lamp is provided under the facia board.

Accessories

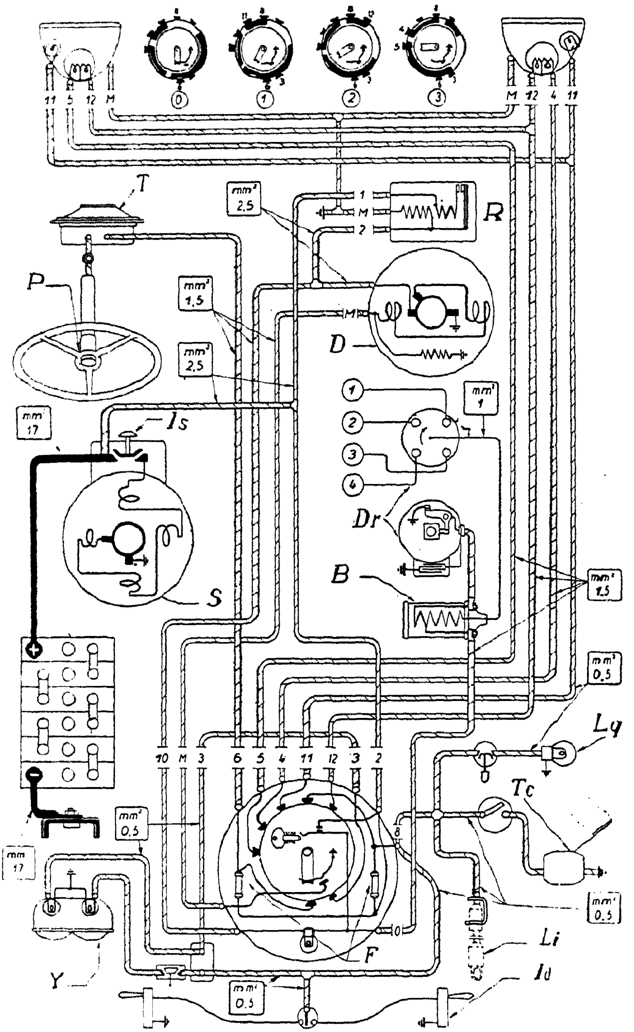
Direction indicators are fitted on the sides of the windscreen, and from chassis No. 014420 are mechanically controlled by a handle located on the upper edge of the facia board. Up to chassis No. 014420 the direction indicators are controlled by means of solenoids arranged behind the instrument board.

Fuses

The two fuses protecting the installation, situated behind the external lighting switch, serve respectively the following :

Right-hand fuse for right-hand headlamp, anti-dazzle lights, town

COMBINATIONS OBTAINED WITH THE EXTERNAL LIGHTING SWITCH



1. ELECTRICAL EQUIPMENT DIAGRAM

The latest key and lock switch is shown, whereby the exterior lighting is controlled by the key which also controls the ignition. B. Ignition coil, D. Dynamo, Dr. Ignition distributor, F. 8-amp. fuses, Id. Direction indicator, Is. Starter switch, Li. Inspection lamp, Lq. Dash lamp, P. Electric horn switch, R. Automatic cut-out, S. Starter motor, T. Electric horn, Tc. Screen wiper, Y. Tail and "stop" lights.

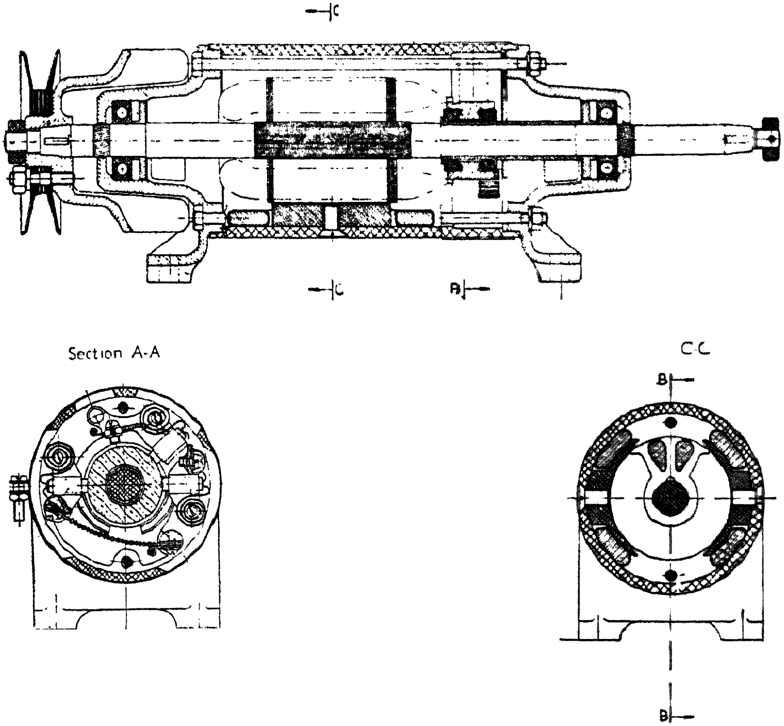


Fig. 2.—Sectional views of dynamo

lights, instrument board light, "stop" light, screen wiper, direction indicators, plug-in socket for inspection lamp; left-hand fuse for left-hand headlamp, electric horn, and tail lamp.

Even when the fuses are burnt out or removed, the circuits for the ignition, the battery charging and the red warning lamp remain active.

For cars up to No. 015734 and between Nos. 016771 and 019839, however, a different switch is incorporated and the fuses provided at its rear protect the following items: the right-hand fuse protects the right-hand headlamp, the lamp for the facia board, the tail light, and the screen wiper. The left-hand fuse protects the left-hand head lamp, the anti-dazzle lights, the town drive lights, the horn, and the direction indicators.

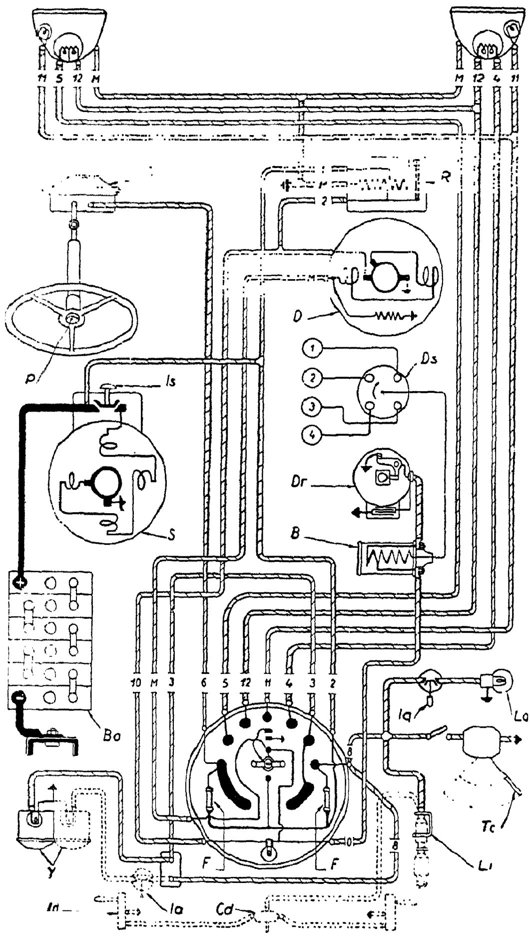


Fig. 3.—ELECTRICAL EQUIPMENT DIAGRAM

In this diagram a lever-controlled switch for the exterior lighting is shown. B. Ignition coil, Ba. Battery, Cd. Direction indicator switch, D. Dynamo, Dr. Ignition contact breaker, Ds. Ignition switch, F. 20-amp. fuses, Ia. " Stop " lamp switch, Id. Direction indicator (optional), Iq. Dash lamp switch, Is. Starter motor switch (operated from dash), Li. Connection for eventual inspection lamp, Lq. Dash lamp, P. Electric horn button, R. Automatic cut-out, S. Self-starting motor, T. Electric horn, Tc. Screen wiper, Y. Tail lamp and " stop " signal.

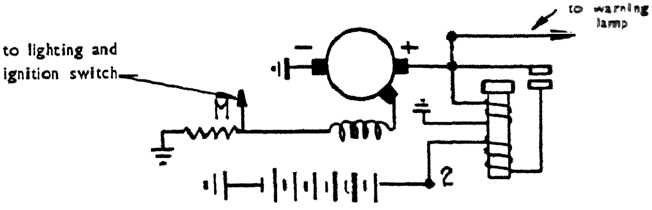


Fig. 4.—DYNAMO CIRCUIT DIAGRAM

The warning lamp indicates when dynamo is not charging battery.

Controls

In the centre is the lock-and-key switch for ignition and external illumination. The key of the lock-and-key switch can be inserted down to the first stop to control the external lights, but to close the ignition circuit it must be pushed farther down.

For cars up to No. 015734 and those between No. 016771 and No. 019839, a different control switch is used. A lever switch for external lighting is provided. In the centre of this switch, a key switch is provided for controlling the ignition. On the pivot of the lever controlling the external lighting switch is a red tell-tale lamp which shows when the dynamo voltage is not sufficient for charging the battery.

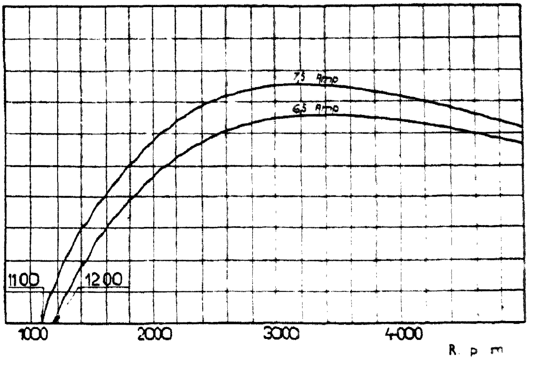
Headlight Alignment

Place the car on level ground, at a distance of 5 metres (nearly 17 feet) from a shadowy white screen. See that the length of the car is square with the screen.

Draw a vertical line on the screen, corresponding to the vertical axis of the car, and then trace on either side of this line a cross at a height of 2 ft. 4 ins. from the floor and at a distance of 3 ft. 2½ ins. from each other.

Fig. 5.—DYNAMO CHARGE CURVES

The maximum charge is the one supplied by the dynamo without field resistance. Maximum charge with warm engine 7·5 amp. Standard charge with warm engine 6·5 amp.



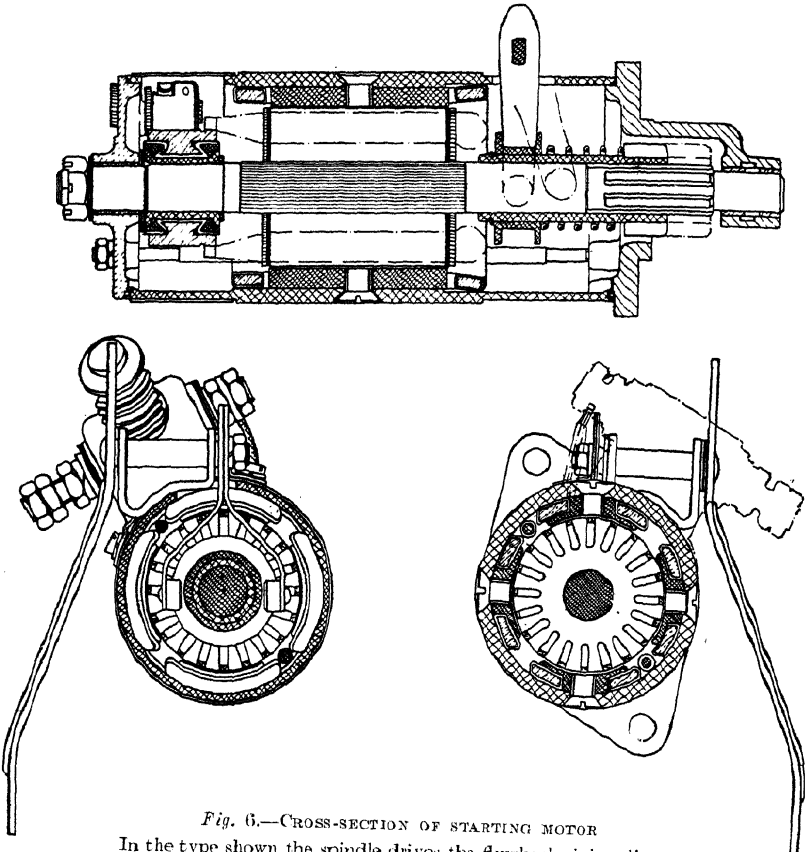


Fig. 6.—CROSS-SECTION OF STARTING MOTOR
In the type shown the spindle drives the flywheel pinion direct.

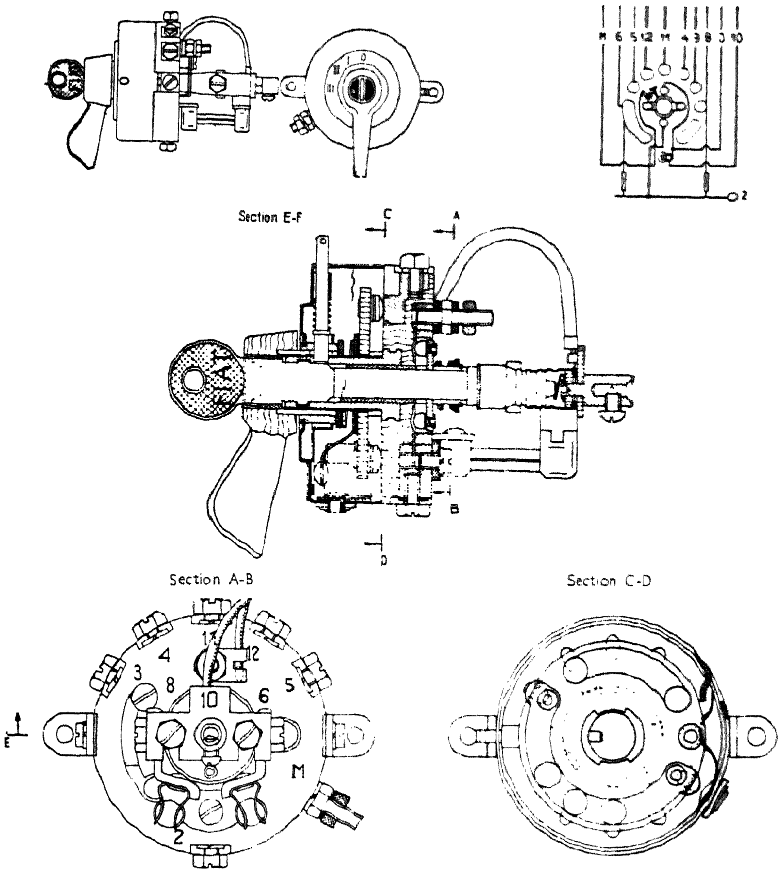
With car unladen, direct the headlamp light straight on to the screen, so as to make the centre of each pool of light coincide with the cross on its side of the vertical line. The headlamps may be adjusted after slackening the lower nut which fixes each to its support.

IGNITION DISTRIBUTOR

The ignition distributor is a Magneti Marelli S 25 F 14 type.

The clearance between the breaker points should be ·016 in. to ·019 in.

The automatic advance device begins to operate when the engine has attained a speed of 200 r.p.m. ; and the maximum advance is reached at 2,800 r.p.m.



—WIRING DIAGRAM AND CROSS-SECTIONAL VIEWS OF AND KEY SWITCH FOR LIGHTING AND IGNITION

Timing the Ignition Distributor

The ignition distributor should be coupled to the engine with 2 degrees advance of t.d.c. As the distributor has an automatic advance of 17 degrees, the total advance amounts to 19 degrees.

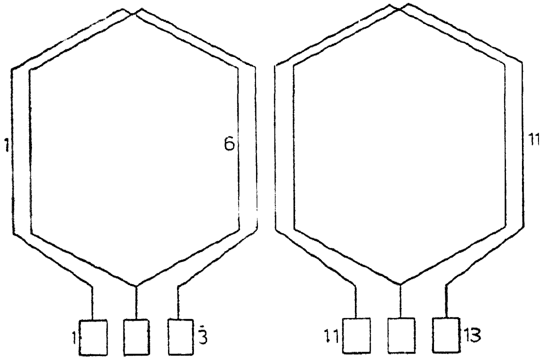


Fig. 8.—DYNAMO ARMATURE COIL WINDING DIAGRAM

IGNITION COIL

The ignition coil is of the Magneti Marelli type. At various engine speeds regular sparks 8 mm. in length should be observed.

The sparking plug gap should be ·015 in. to ·020 in.

DYNAMO

The dynamo is of the Fiat 75/12 type, giving 75 watts. It has two poles and 3rd-brush-and-resistance regulation. It begins to charge (on top gear) at $12\frac{1}{2}$ m.p.h. The maximum output with headlamps off is 6·5 amp., and with headlamps on, 7·5 amp. The rotation (coupling end) is clockwise. The transmission ratio: $\frac{\text{engine}}{\text{dynamo}}$ is 1 : 1·25.

Adjusting Tension of Dynamo Driving Belt

The pulley on the dynamo spindle consists of two outer discs with several intermediate spacing rings forming the pulley groove. When the belt becomes slack it should be drawn off and the pulley dismantled. One or two of the spacing rings should then be moved to the outside of the pulley side discs. In this way the pulley groove will be made narrower and the belt will be tightened.

Automatic Cut-out

Data for adjustment: spring tension against the contact holder, about 10 oz. Gap between iron core and contact holder, from ·02 in. to ·04 in. closed. Closed contact voltage 12·5 at 770 r.p.m. Disconnection output, 2·5 to 3 amps.

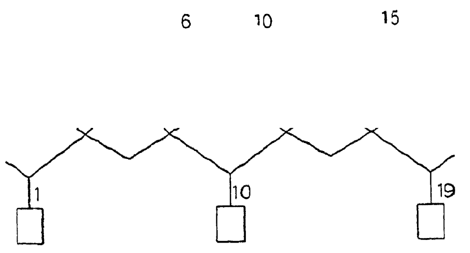


Fig. 9.—STARTER MOTOR ARMATURE COIL WINDING DIAGRAM

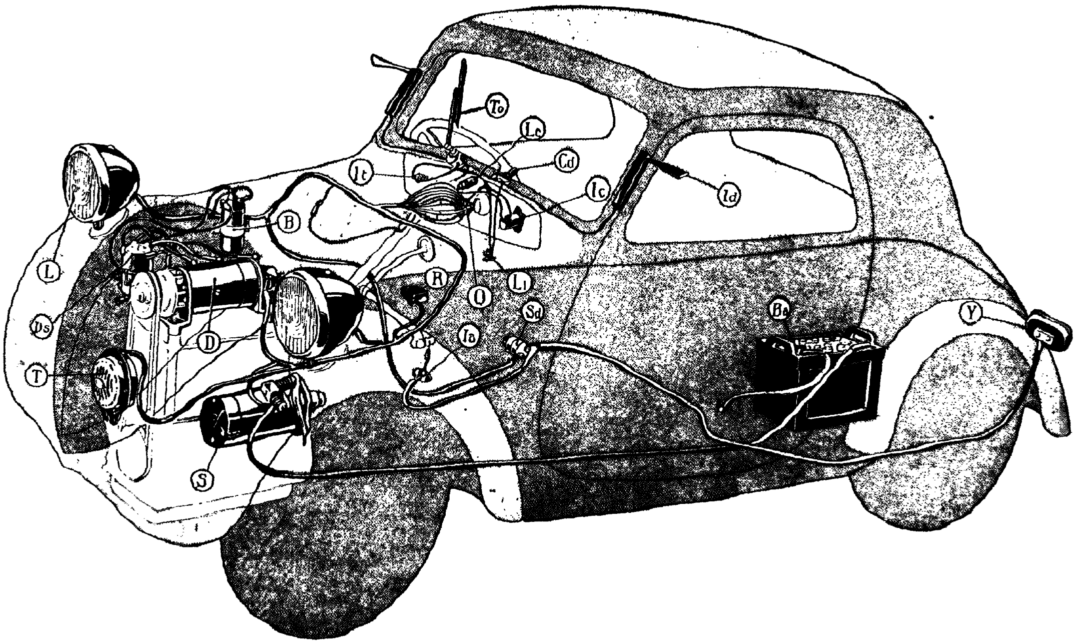


Fig. 10. ELECTRICAL EQUIPMENT WIRING DIAGRAM

B. Ignition coil. Ba. Battery. Cd. Manual control for direction indicators. D. Dynamo. Ds. Ignition distributor. Ia. "Stop" lamp switch. Ic. Switch for dashboard lamp. Id. Direction indicators. It. Screen-wiper switch. L. Headlamps. Lc. Lamp for dashboard and internal light. Li. Plug in socket for inspection lamp. Q. Switch for external lighting and ignition, with tell-tale lamp for battery charge. R. Automatic cut-out. S. Self-starter motor. Sd. Junction box. T. Electric horn. To. Screen-wiper. Y. Tail and "Stop" lamp.

REWINDING DATA

Dynamo Windings

In case of a rewind, the coil winding data is as follows :

Armature Windings—symmetrical. 12 slots, 24 comm. bars. Winding pitch 3 + 5. Pitch to the commutator + 1. 52 wires per slot. 4 coils per slot. 13 turns per coil. Total 624 turns. Diameter of bare wire ·03 in. Diameter of insulated wire (enamel and double cotton covered), maximum $\frac{3}{64}$ in.

Field Windings.—2 poles. 212 turns per pole. Diameter of copper wire 0·70 mm.

Starter Motor

The construction of the starter motor may be seen from Fig. 6. Maximum power developed is 0·70 h.p. Rotation (pinion end) is clockwise. Transmission ratio, engine : motor is 1 : 8·4.

Starter Motor Windings

The following winding particulars may be useful in case a rewind is necessary.

Armature Coils.—Series winding. Winding pitch, 5. Pitch to commutator, 9. 19 slots, 4 wires per slot, 38 coils. 2 turns per coil, 76 turns in all. 19 commutator bars. Diameter of insulated wire 2·1 to 2·3 mm.

Field Coils.—4 poles. 5 turns per pole. Copper section 4·8 sq. mm.

HUDSON & TERRAPLANE ELECTRICAL EQUIPMENT

SINCE 1937, 12-volt electrical equipment has been used on Hudson and Terraplane cars in this country. Wiring diagrams and details applicable to the 12-volt equipment for the 1937, 1938, and 1939 models are therefore given in this section.

Hudson 16·9 (1939)

Fig. 1 shows the wiring diagram of the Hudson 16·9. Details of the electrical equipment are as follows :

A 12-volt 75-amp. 11-plate Exide-type 6XCK.11 battery is used. The dynamo has a charging rate of 8 amps. on cars fitted with a dynamo relay ; where a voltage regulator is installed for radio the rate is 12·5 amps. ; adjustment is made by means of the third brush. Lamp data : headlamps, 36 watts each, D.C. base ; side lamps, 4 watts, S.C. ; instrument lamps, 3 watts, S.C. ; dash signals, 2 watts, S.C. ; dome lamp, 9 watts, S.C. ; licence-plate lamp, 4 watts, S.C. ; " stop " and tail lamps 18 and 3 watts, D.C. ; indicator signals, 3 watts, festoon ; beam indicator, 2 watts, S.C. ; and service lamp, 3 watts, S.C.

Fuse data for the Hudson 16·9 car is : lighting circuit fuse, 20 amps. ; accessory circuit fuse, 20 amps.

Hudson " Six " 21·6 (1939)

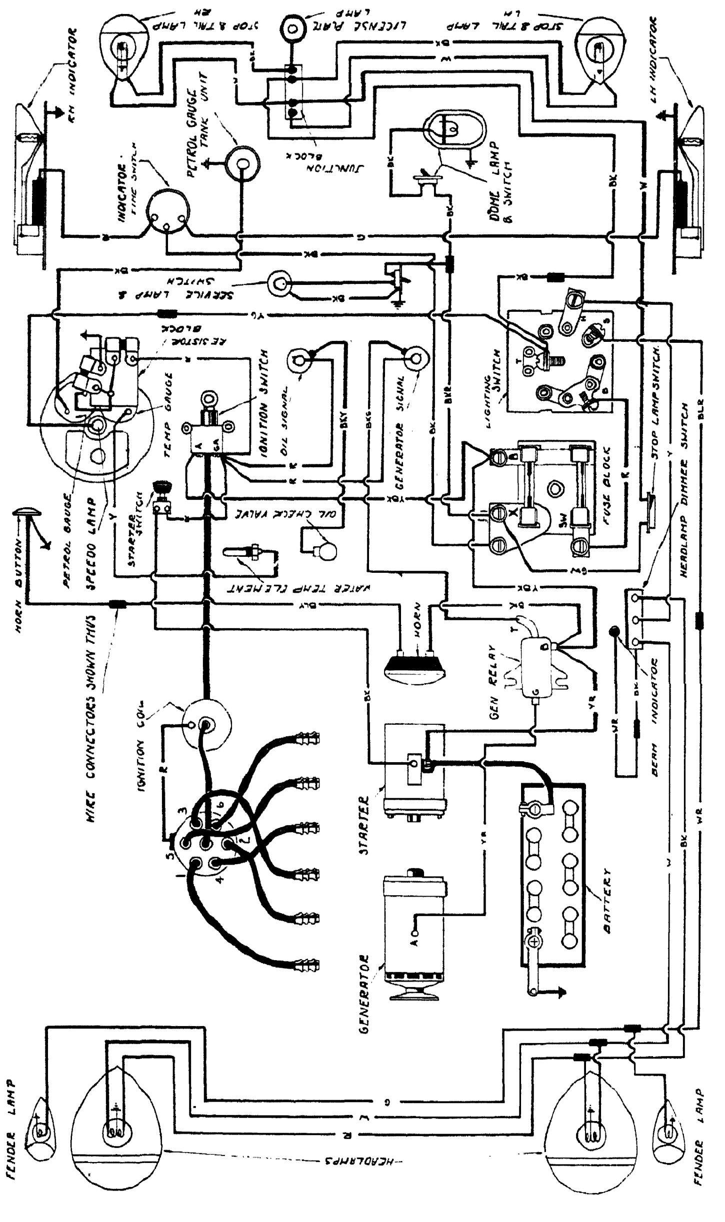
The wiring diagram of the Hudson 21·6, 1939 model, is shown in Fig. 2. Battery, lamp bulb, and fuse particulars are as for Hudson 16·9, 1939 model. The speedometer and clock lamp is 3 watts, S.C. The dynamo charging rate is 12·5 amps., adjustment being by means of third brush.

Hudson and Terraplane (1938)

The wiring diagram of the Hudson Terraplane (1938) model, is shown in Fig. 3. An Exide 75-amp.-type 6XCM.11–1 battery is used. The dynamo of the standard series, i.e. cars not fitted with voltage regulator, is 8 amps. On the De Luxe series and all Hudson models the rate is 12·5 amps. Adjustment is made by means of the third brush.

There are two fuses of 20 amps. controlling the lighting and accessory circuits.

The wattages for the lamps are similar to those given for the Hudson


RH INDICATOR
STOP & TAIL LAMP RH
LICENSE PLATE LAMP
STOP & TAIL LAMP LH
LH INDICATOR
PETROL GAUGE TANK UNIT
INDICATOR TIME SWITCH
JUNCTION BLOCK
DOME LAMP & SWITCH
SERVICE LAMP & SWITCH
RESISTOR BLOCK
TEMP GAUGE
IGNITION SWITCH
OIL SIGNAL
GENERATOR SIGNAL
LIGHTING SWITCH
STOP LAMP SWITCH
PETROL GAUGE
SPEEDO LAMP
STARTER SWITCH
OIL CHECK VALVE
FUSE BLOCK
HEADLAMP DIMMER SWITCH
HORN BUTTON
WATER TEMP ELEMENT
WIRE CONNECTORS SHOWN THUS
HORN
GEN RELAY
BEAM INDICATOR
IGNITION COIL
STARTER
BATTERY
GENERATOR
FENDER LAMP
HEADLAMPS
FENDER LAMP

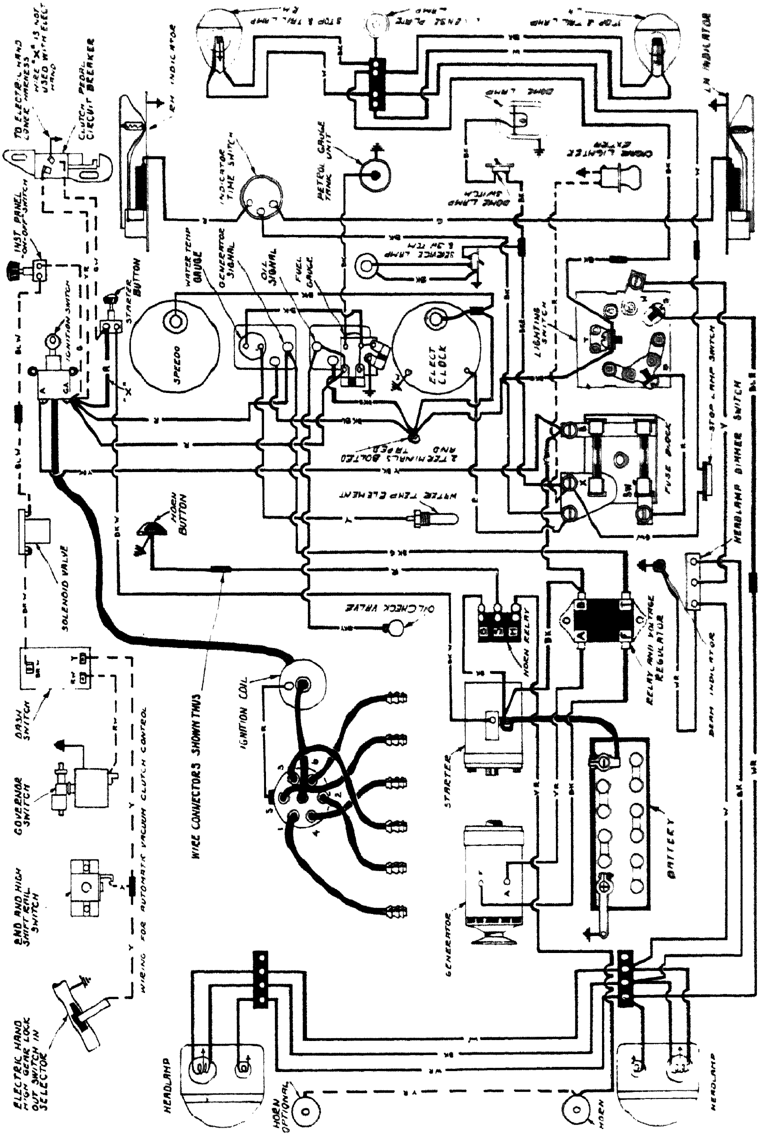


Fig. 2. WIRING DIAGRAM OF THE HUDSON "SIX" 21-6 SERIES (1939)

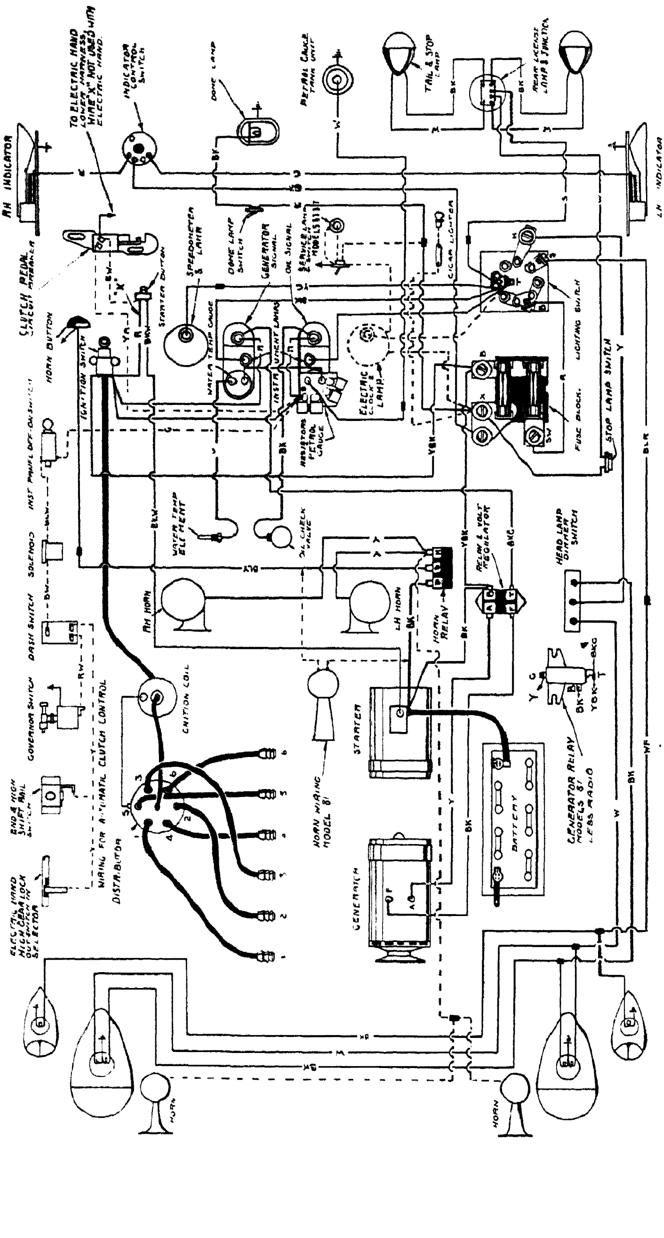


Fig. 3.—WIRING DIAGRAM OF THE HUDSON AND TERRAPLANE (1938)

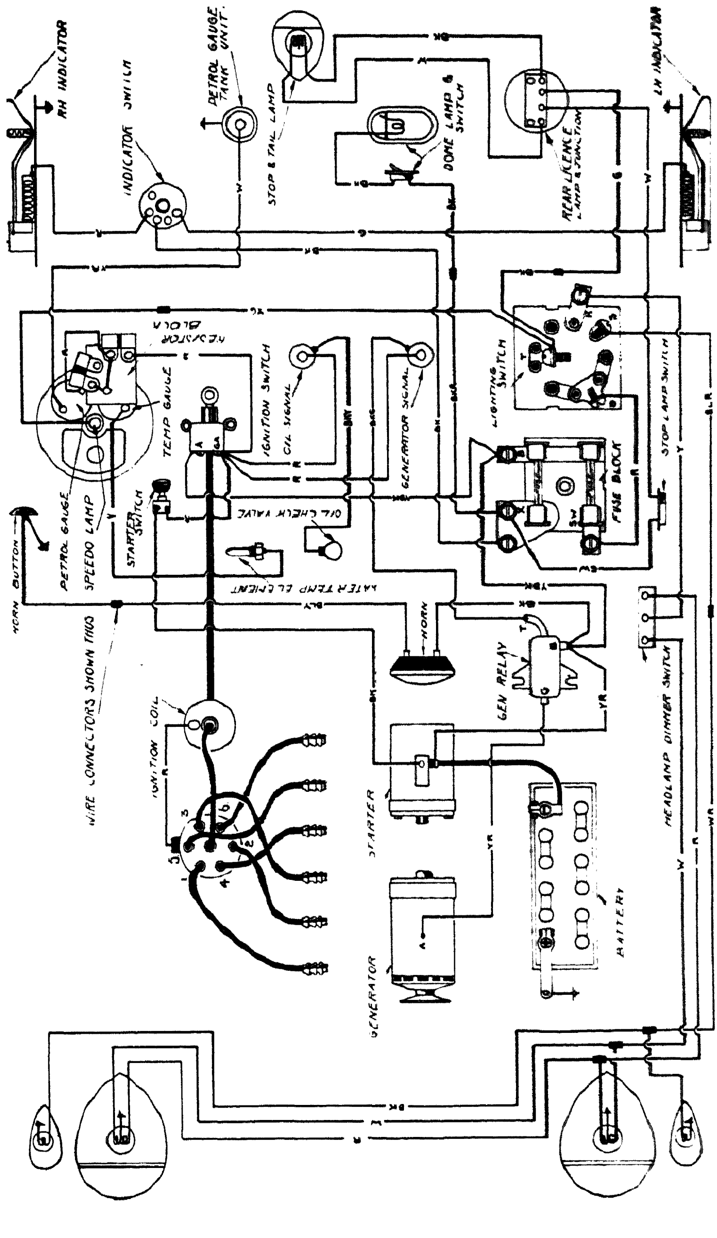


Fig. 4. WIRING DIAGRAM OF THE HUDSON 112/89 SERIES CARS (1938)

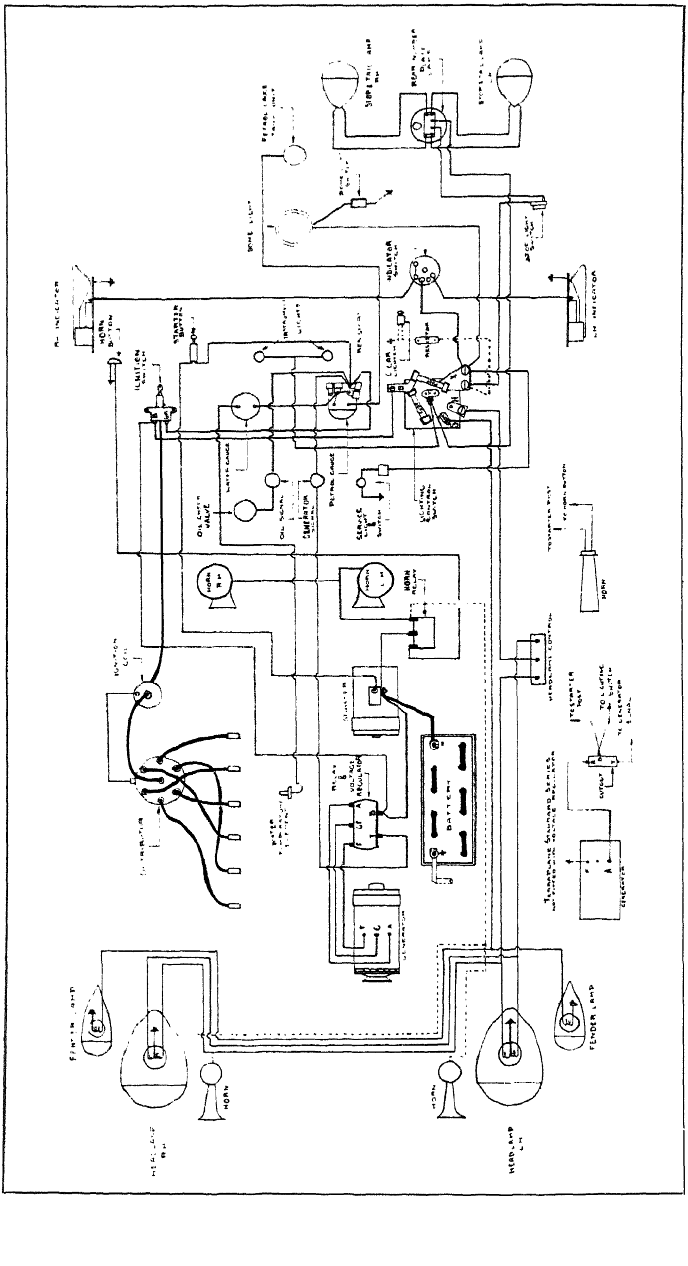


Fig. 5.—WIRING DIAGRAM OF HUDSON AND TERRAPLANE 1937 SERIES CARS

16·9, except the dome lamp (6 watts, S.C.) and the tail and "stop" lamp (21 and 6 watts, D.C.). The indicator-switch lamp is ·3 amp., S.C.

Hudson 112/89 series (1938)

The wiring diagram for this car is given in Fig. 4, and the battery and fuse data are as for the Hudson Terraplane of the same year. The charging rate on cars fitted with a generator relay is 8 amps. Where a voltage regulator is installed for radio, the rate is 12·5 amps.

The lamps fitted are: head, 21 and 50 watts, D.C.; side, 3 watts, S.C.; instrument, 3 watts, S.C.; dash signals, 1·5 watts, S.C.; dome, 15 watts, S.C.; licence plate, 3 watts, S.C.; tail and "stop," 21 and 6 watts, D.C.; indicator signals, 3 watts, festoon; indicator-switch lamp, ·3 amp., S.C.

Hudson and Terraplane (1937 series)

The wiring diagram for these cars is given in Fig. 5. The battery and charging rate are as given for the 1938 Hudson and Terraplane.

Lamp bulbs are: headlamps, 40 watts each, D.C.; side, instrument, service light, licence-plate lamps, 3 watts, S.C.; tail and "stop," 21 and 6 watts, D.C.; dome eight, 15 watts, S.C.; dash signals, 2 watts, S.C.

THE ELECTRIC HAND

The electric hand provides a means of changing the gears of an ordinary gearbox by mechanical power. The control of the mechanism is electrical, while the power for the changing is derived from the vacuum of the engine-intake manifold.

Clutch Circuit Breaker

When the clutch is engaged the electrical supply circuit to the electric hand is open, so that it is necessary to disengage the clutch before a gear change can be made. This circuit breaker is operated through linkage to the clutch pedal, which is adjustable to determine the exact amount of clutch disengagement before the circuit is closed and a change made, and also the amount of clutch engagement before the power is again cut off.

The Selector Switch

The selection of the gear desired in the gearbox is made by moving the lever of the selector switch to the corresponding position in the H-plate of the selector-switch housing. This selects the proper circuit to control the shifting mechanism.

The Interlock Switch

This switch interrupts the circuit from the selector switch to the power unit to insure a change to neutral to permit a cross-change, if this is necessary before the final movement of the change is made. The

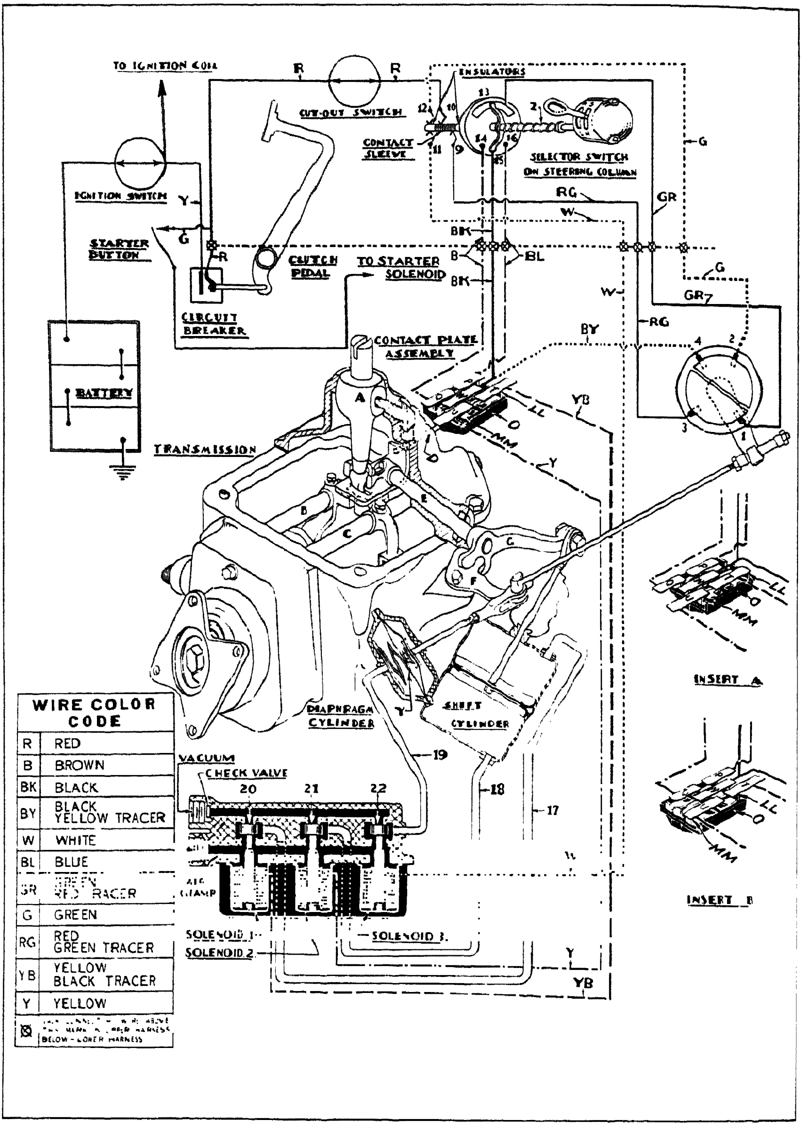


Fig. 6.—THE ELECTRIC HAND (1935–36 MODELS)—SELECTOR IN NEUTRAL POSITION

switch is mechanically controlled by linkage from the cross-chang mechanism. This linkage is adjustable and incorporates a "lost motion" sleeve to ensure the completion of the cross-change before the circuit is changed to correspond to the one selected in the selector switch. Without this switch, preselection from one gear to another which requires a cross-change would be impossible, while any change would have to be made slowly to ensure the mechanism following the control movement.

Contact Plate

A contact plate on the earlier models opens the circuit after the gear change has been completed. This switch is controlled by a rod connected to the bottom of the changing lever (*A*) (Fig. 6).

Power Unit—Solenoids and Valves

The selector switch, interlock switch, and contact plate control the electrical connections to three solenoids, each of which operates a valve. These valves are connected in the vacuum line from the engine-intake manifold, and control the vacuum to the cross-change or diaphragm cylinder and power cylinder. The valves are of the poppet type and are held up by small springs. When a solenoid is energised, the valve which it controls is pulled down.

When the valves are in the upper position, the vacuum line is closed from the engine and the lines to the diaphragm cylinder and power cylinder are open to atmosphere.

When the valves are in their lower position, the vacuum line from the engine is connected to the diaphragm cylinder or power cylinder.

One valve controls the cross-change, one the forward, and one the rearward movement of the gearbox change rails.

Power Cylinder

The power cylinder has a vacuum-operated piston which provides the power for the forward and rearward movement for changing the gears. When the valve (21) (Fig. 6) in the vacuum line to the rear of the power cylinder is drawn down by its solenoid, opening the vacuum line, the piston moves backward. When the valve (20) in the vacuum line to the front of the power cylinder is drawn down by its solenoid, the piston moves forward. The movement of the piston is transmitted to the changing lever (*A*) through the control cross-shaft (*E*) and inner and outer levers.

Cross-change Cylinder

The cross-change cylinder is of the diaphragm type. A spring (*Y*) (Fig. 6) in the cylinder presses the diaphragm forward, which, through connecting linkage (*F*, *G*, *E*), holds the change lever (*A*) of the transmission engaged with the high- and second-speed change-rail fork (*B*)

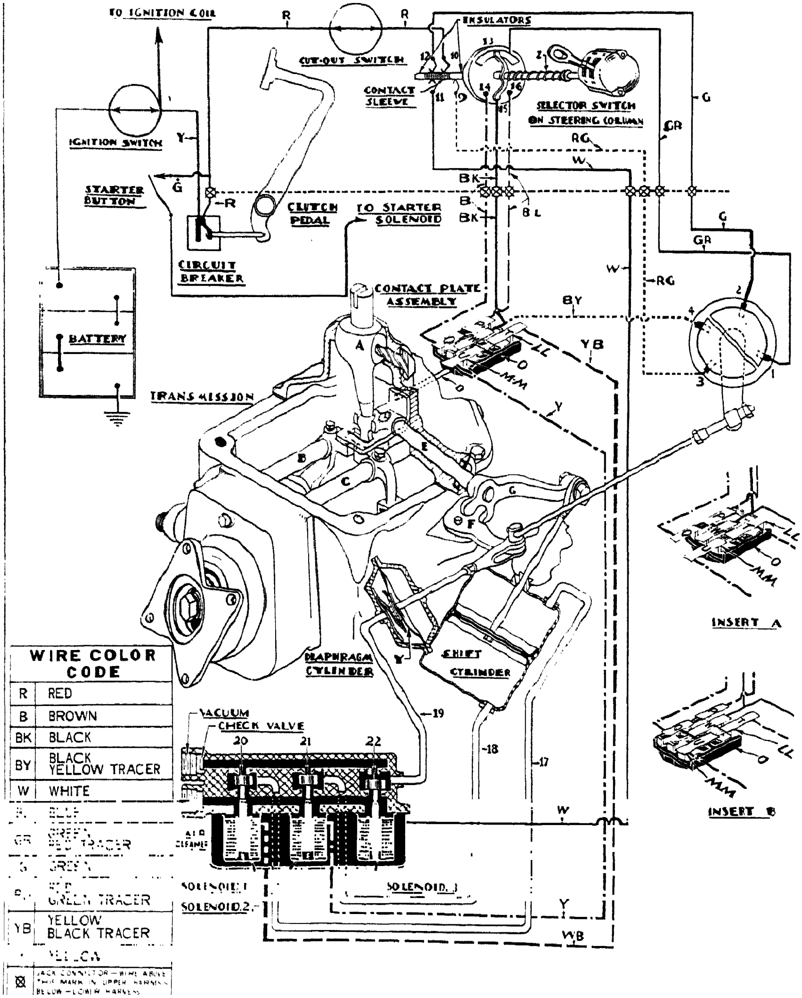


Fig. 7.—THE ELECTRIC HAND (1935-36 MODELS)
The selector in neutral position but pushed to the left.

(Fig. 6). When the valve (22) connected to the cross-change cylinder is drawn down by its solenoid, the diaphragm moves backward, pulling the bellcrank (*F*) which moves the control shaft (*E*) to the right to engage the lower end of the change lever (*A*) with the low and reverse change-rail fork (*C*). This position is shown in Fig. 7.

Operation (1935–36 models)

Fig. 6 shows the selector in neutral, with the lever held to the right by the spring (*Z*). The gears are also in neutral, and the lower end of the change lever (*A*) is held to the right by the spring (*Y*) in the diaphragm cylinder, so that it is engaged in the notch of the high and intermediate change fork (*B*).

The valves (20), (21), and (22) are up against their seats, so that both the front and rear of the power cylinder and the cross-change cylinder are open to the atmosphere through the air cleaner.

If the clutch is depressed, closing the circuit breaker, the circuit will be closed to (10), through the contact sleeve to (9), to (3) and (1) on the interlock switch to (13) on the selector to (15) to plate (*W*) of the contact plate. Since the fingers (*LL*) and (*MM*) do not touch the plate (*W*), the circuit is open.

If, however, the gearbox were in high gear, the contact-plate sliding block (*O*) would have moved forward to the position of Insert A. The fingers (*MM*) would be contacting plate (*W*) and would close the circuit to plate (*U*) to solenoid No. 2. The valve (21) would be pulled down, connecting the rear of the power cylinder to the vacuum, so that the piston would move backward and, through the linkage (*G*, *E* and *A*), move the change rail (*B*) backward. The rod (*D*) would also be moved backward, pulling the contact-plate sliding block until the fingers (*MM*) break contact with the bar (*W*). When circuit is broken, the valve (21) raises to its seat and the change is completed to neutral.

If the gear had been moved to second, the contact plate would have been in the position shown in Insert B, completing the circuit from (*W*), through fingers (*LL*) to plate (*T*) to solenoid No. 1, opening the vacuum to the front of the power cylinder so that the piston would be moved forward, bringing the gearbox into neutral, where the fingers (*LL*) would break contact with bar (*W*) and the change would be completed to neutral.

Fig. 7 shows the same condition as in Fig. 6, except the selector lever has been pushed to the left but is still in the neutral position. It will be noted that the circuit from (10) in the selector switch is now completed through the contact sleeve to both (11) and (12).

The circuit from (11) is direct to solenoid No. 3, so that valve No. 22 is drawn down, connecting the cross-change cylinder to the vacuum. The diaphragm has moved backward, rotating bellcrank (*F*) which pulls lever (*G*), shaft (*E*), and the lever (*A*) to the right so that (*A*) is engaged in the

notch of the shifting fork of rail (*C*), which controls the change into low and reverse gears.

The circuit from (12) is to (2) and (1) on the interlock switch, to (13) to (15) on the selector switch to bar (*W*) on the contact plate. Now, following the same procedure as under Fig. 6 it will be seen that, if the gearbox were in low gear, the contact plate would be in the position of Insert A (same as for high gear), energising solenoid (2) and the change would be to neutral. If the gear were in reverse, the contact plate would be in the position of Insert B (same as for second gear), energising solenoid (1) and the shift would be to neutral.

Referring again to Fig. 6, it will be seen that if the selector lever is moved to the high-gear position (transmission in neutral), the circuit will be completed as before to (13) on the selecton switch, then to (16) to (*P*) on the contact plate through the fingers (*LL*) to (*T*) to solenoid 1, and the change rail (*B*) will be moved forward until the contact plate reaches the position of Insert A when the fingers (*LL*) will move off bar (*P*), opening the circuit.

If the selector lever is now moved to the second-gear position (transmission in high or neutral), the circuit from (13) is to (14) on the selector switch to bar (*Q*) through the fingers (*MM*) to bar (*U*), to solenoid 2, and the movement of the rail (*B*) will be backward until the fingers (*MM*) move off bar (*Q*), opening the circuit as in Insert B.

Referring to Fig. 7, the action will be the same for low and reverse as just explained for high and second as the lever (*A*) is held in engagement with the change rail (*C*) and all other circuits are identical.

In order to shift from low to high, the power-cylinder piston must first move backward and bring the transmission to neutral. The circuit for this is through the lines from (10) to (9) and (3) to (4) on the interlock to bar (*W*) on the contact plate. The circuit is closed from (*W*) through the fingers (*MM*) to bar (*U*) to solenoid 2, so that the movement will be backward until the fingers (*MM*) break contact with the bar (*W*) which occurs when the gear is in neutral.

When the change rail (*C*) reaches the neutral position, the force of the spring (*Y*) in the diaphragm cylinder will pull the change lever (*A*) to the left into engagement with the notch of the high and second change fork (*B*). As the cross-change is completed the interlock switch will be moved.

Now the circuit from (3) in the interlock switch is to (1) to (13) to (16) to bar (*P*) in the contact plate. The contact plate having moved back in coming to neutral the contact is now completed from (*P*) through fingers (*LL*) to (*T*) to solenoid 1 and the piston is moved forward, moving rail (*B*) forward to the high-gear position where the fingers (*LL*) open the contact with bar (*P*) as at the beginning of the change from low gear.

Had the selector lever been set in the second-gear position the movement to neutral would have been the same as for high gear. From

neutral the movement would have been backward to second (instead of forward to high), as the circuit would have been completed from (13) to (14) (instead of to (16)) to bar (*Q*) through (*MM*) to (*U*) to solenoid 2.

Also, had the gear been in reverse instead of low, the contact plate would have been to the rear, and the circuit from bar (*W*) would have been through fingers (*LL*) to bar (*T*) to solenoid 1, and the movement would have been forward to neutral.

If the transmission is in high-gear and the selector in low-gear position, the circuit is through the interlock switch to bar (*W*) to bring the gear to neutral. When the lever (*A*) reaches the neutral position it will be drawn to the right to engage with the fork on change rail (*C*), since the circuit is complete from (11) to solenoid 3 and the interlock switch will be rotated to the proper position.

The circuit from (2) on the interlock switch is now to (1) and follows the path indicated by the lines to plate (*P*) on the contact plate. Since the contact plate has been moved to the neutral position, the circuit is now completed from (*P*) through (*LL*) to (*T*) to solenoid 1, so that the change rail (*C*) is moved forward to the low-gear position.

Had the selector switch been set in reverse, connecting (13) and (14), the circuit would have been completed to (*Q*) through (*MM*) to (*U*) to solenoid No. 2, causing a normal neutral-to-reverse change.

Mechanical Adjustment

The entire mechanical adjustment is so important to proper functioning that it should be made carefully with every servicing of the electric hand. The recommended procedure is as follows :

The Clutch Circuit Breaker (1935)

With clutch fully engaged, the pointer on the lever should be in line with the arrow on top of the circuit-breaker housing.

To adjust : (1) When equipped with automatic clutch control—loosen clamp-bolt nut on bracket mounted on vacuum-clutch rod and slide clip until pointer is in line with arrow. Tighten locknut.

(2) When not equipped with automatic clutch control—remove cotter key from circuit-breaker lever pin. Loosen locknut on operating rod and remove rod end from lever pin. Turn rod end until it will slip on pin with pointer in line with arrow on housing. Insert cotter pin and tighten locknut.

The position of the circuit-breaker lever is important. If the contact is made with too little clutch-pedal movement, the clutch will still be engaged when the shift is made, and if a gear has been pre-selected the shift will be made while the engine is driving the car. If the contact requires too much pedal movement, the shift will not be completed should the gears butt teeth. It is necessary to have a slight clutch drag before the circuit is broken to turn the gears and ensure engagement. It

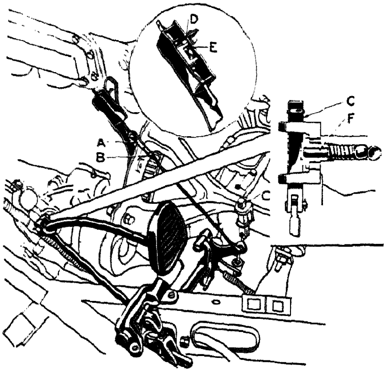


Fig. 8.—ADJUSTMENT OF CLUTCH CIRCUIT BREAKER—CIRCUIT CLOSED POSITION

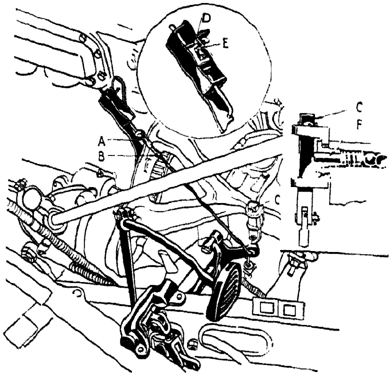


Fig. 9.—ADJUSTMENT OF CLUTCH CIRCUIT BREAKER—CIRCUIT OPEN POSITION

may be necessary, therefore, to set circuit breaker slightly ahead of indicating arrow.

The Clutch Circuit Breaker (1936-7)

This clutch circuit breaker has lost motion built into the switch, so that the clutch pedal must be depressed far enough to disengage the clutch before the electric-hand circuit is closed, but the circuit will not be opened until the clutch is almost fully engaged. If the clutch is not disengaged before the change is made, it will cause the gears to clash. Opening of the electric-hand circuit before the clutch has started to engage will result in failure of the gears to mesh, if the car is not in motion and the gear teeth strike end to end.

The locknut (*B*) should be loosened and yoke (*A*), Fig. 8, on the rod, which operates the clutch circuit breaker, should be adjusted so that the clutch pedal must be depressed halfway to the toe-board before the circuit is closed. The upper insert in Fig. 8 shows the position of the parts inside the circuit breaker at the point where the circuit is closed. (*D*) is the stationary contact and (*E*) the sliding contact.

At the time the circuit is closed the gear change rail locks must be released so that the shift can be made. The lower insert in Fig. 8 shows the proper position of the lockbar link (*C*) and plunger (*F*).

After adjusting the circuit breaker for point of closing, check to be sure that the clutch has begun to take hold before the circuit is opened.

This check is most readily made by running the engine and putting the gears in low or reverse gear. Allow the clutch pedal to come up slowly.

The car should start to move before the "click" of the cross-shaft linkage is heard, indicating that the electric-hand circuit has been opened.

The insert of the circuit breaker in Fig. 9 shows the position of the parts at the point where the circuit is opened, while the change rail lock bars must be down, as shown in the lower insert, to ensure the gearbox being locked in gear before the electric-hand power is cut off. This is important, to prevent the jumping out of gear.

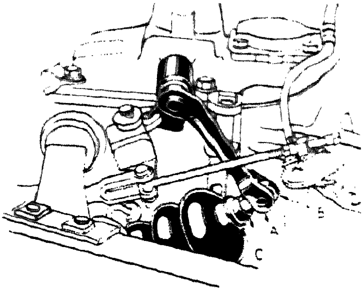


Fig. 10. —POWER-UNIT MOUNTING ADJUSTMENT

Power-unit Mounting

The power-cylinder piston rod (*B*), Fig. 10, should enter the fork (*A*) in the change lever easily, when the transmission is in either its forward (high) or rearward (second) position. The power unit should also have sufficient clearance to prevent striking the frame cross-member. Maximum clearance is obtained by pushing upwards on the unit while tightening the nuts on the studs which hold the mounting bracket to the gearbox. The nut on the power-cylinder mounting stud should be drawn up just enough to permit the insertion of the cotter key. This provides maximum flexing of the rubber blocks for alignment.

Power-cylinder Piston-rod Alignment (1935–6)

Remove the clevis pin from the rod eye. With the transmission in high gear and the shifting lever held forward to take up lash, it should be possible to pull the piston rod (*B*) through the fork lever (*A*) ¼ in. farther than the piston, where the clevis pin can be inserted. The length of the rod can be adjusted by loosening the locknut (*C*) and turning the eye.

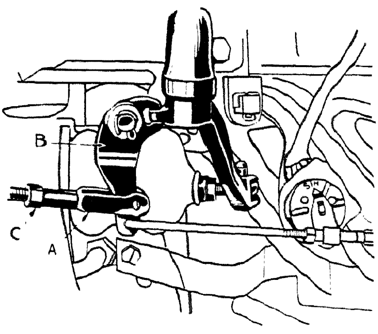


Fig. 11. CROSS-CHANGE CONTROL-MECHANISM ADJUSTMENT

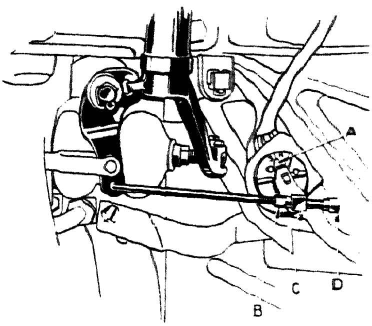


Fig. 12. CROSS-CHANGE MECHANISM ADJUSTMENT

The piston rod should then be pushed back and the gear shifted into second. While pushing backward on the shift lever to take up lash in the linkage, the piston rod should be $\frac{1}{4}$ in. farther back than the position where the clevis pin can be inserted. These checks are important, to ensure sufficient travel of the piston in both directions to complete the shifts.

Cross-change Control Mechanism

The gearbox should be changed to all positions and the contact between the cross-shift bellcrank and the lobe on the power-cylinder change lever checked to see that there is no binding due to contact at points other than the ends of the bellcrank fork (*B*), Fig. 11.

The movement of the lower change lever should also be checked, to see that the fulcrum dowel screw does not bind in the groove in the lever ball. Early 1936 production used a dowel screw which was $\frac{23}{32}$ in. long under the head with a $\frac{1}{16}$-in. plain washer in addition to the lock. Later production uses a screw $\frac{21}{32}$ in. long and the plain washer is omitted.

Cross-change Mechanism Adjustment

With the gear in high or second, remove the clevis pin from the diaphragm cylinder-rod yoke (*A*), Fig. 11. The spring in the cylinder should hold the yoke $\frac{1}{4}$ in. farther forward than the position in which the clevis pin can be inserted. When loosening or tightening the nut (*C*) on the diaphragm cylinder rod, be sure the yoke is in place on the bellcrank, so that the diaphragm is not twisted and distorted.

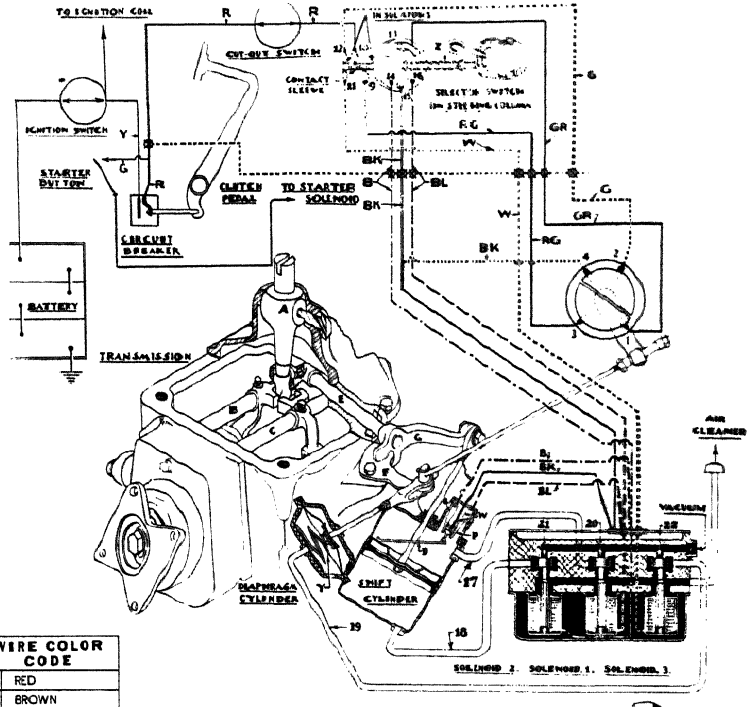
Interlock Switch

After the gear is moved from low to high or second gear, the pointer (*A*), Fig. 12, on the interlock-switch lever should come to rest in line with the mark between the letters S and H on the switch cover. To adjust, loosen the nut (*D*) on the front end of the interlock-switch rod and turn the adjusting sleeve (*B*), then retighten the nut.

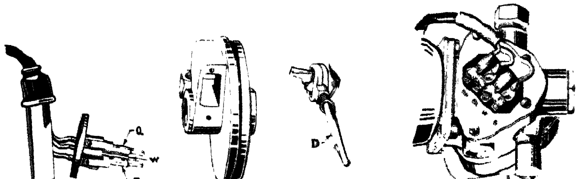
When the length is correct, the circuit will change in the interlock switch at the same distance from the end of cross-shift travel in both directions.

Transmission Shifting Rail Lock

The locks on both change rails will definitely prevent the gears from jumping out if they are in the locked position when the change is completed and the clutch is engaged. If the locks are improperly adjusted or the change is not complete, the locks cannot perform their normal function, and damage to the gear teeth will result. As a final check move into gear and engage the clutch and see that the lockbars are both down in the locked position. If the locks are not down, first check the lock



WIRE COLOR CODE	
R	RED
B	BROWN
BK	BLACK
BY	BLACK YELLOW TRACER
W	WHITE
BL	BLUE
GR	GREEN RED TRACER
G	GREEN
RG	RED GREEN TRACER
⊠	JACK CONNECTOR — WIRE ABOVE THIS MARK IN UPPER HARNESS, BELOW — LOWER HARNESS



g. 13. – Mechanism and Wiring of Electric-Hand Installation

adjustment, then power-cylinder piston-rod length, then the point of breaking contact in the clutch circuit breaker.

If these adjustments are correct and the lockbars do not fall into place when the clutch is released, it is probably due to the power being cut off in the contact plate before the change is completed.

Preliminary Service Check

The following are to be checked before attempting to make any repairs to the gear shift-control mechanism, regardless of the nature of the failure :

(1) Be sure cut-out switch on selector housing is " on."

(2) Be sure that the gears are free and can be moved into all positions manually with clutch pedal depressed just enough to close circuit through clutch circuit breaker. (Check by pressing starter button.) Adjust interlock bars on gearbox if necessary.

(3) If temperatures are encountered low enough to cause the recommended gearbox lubricant to excessively retard gear changing, replace 3 oz. of the lubricant with paraffin.

(4) Inspect vacuum line and fittings for leaks.

(5) Check wire connections on interlock switch.

(6) Make certain that all clevis pins and cotter pins are in place.

(7) Inspect junction block on power unit to see that all wires are in place.

(8) Make certain that all soldered connections are intact in both portions of steering-column jack. (To remove covers, pull back and twist with jack assembled.)

(9) Check wiring harness for breaks or damaged insulation.

Quick Test for Short-circuit

With instrument-panel lamp lighted, change into all positions with electric hand. Any appreciable dimming of instrument lamp indicates short-circuit in that position.

Electric Hand on 1936–7 Models

The changes in the electric hand which became effective in 1936 are confined to the power unit, lower harness, and gearbox control cover. A neutral switch and the necessary driving mechanism has been incorporated in the power-cylinder head. This neutral switch eliminates the need for the contact plate. The contact plate has been removed from the transmission control cover, simplifying the linkage in this unit and eliminating the wiring in the lower harness which was required for the contact plate.

Operation (1936–7)

Fig. 13 shows the mechanism and wiring of the complete electric-hand installation. With the selector and gear in neutral as shown, the circuit is complete to the centre terminal of the neutral switch. Since

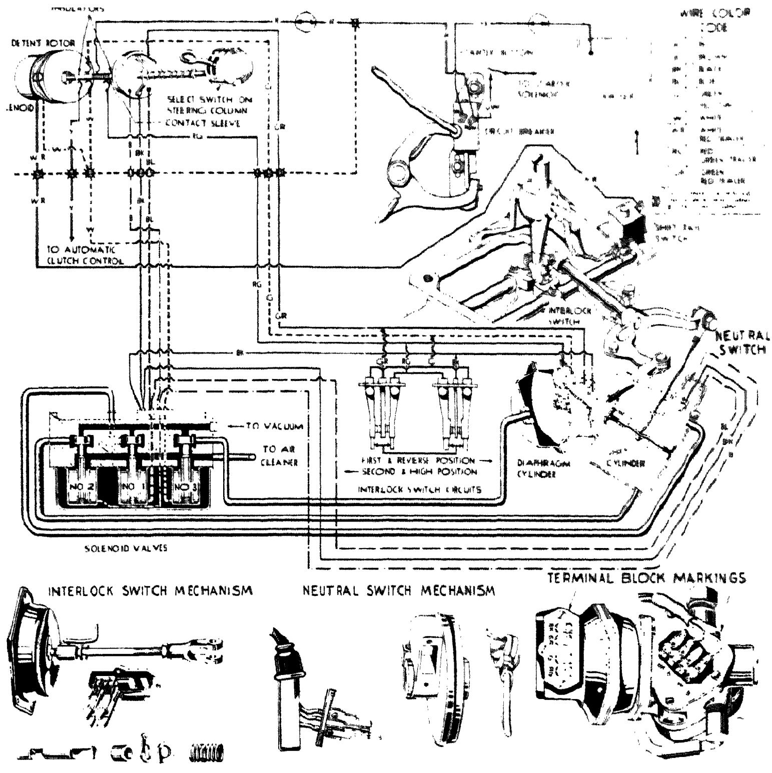


Fig. 14.—ELECTRIC HAND-WIRING DIAGRAM (1938)

neither point (*P*) nor (*Q*) contacts the centre terminal (*W*), the circuit is broken at this point and the gears will remain in neutral.

If the gear is shifted manually towards high gear, the power-cylinder piston will move forward, moving the rod (*D*), which will move point (*P*) farther away from the central contact (*W*), and allowing point (*Q*) to come into contact with the central contact. This will close the circuit to solenoid 2, which will pull the valve down, admitting vacuum to the rear of the power cylinder. The piston will move backward until contact (*Q*) is moved away from the central contact (*W*), which is the neutral position.

It will be seen that had the gear been moved toward second, contact (*P*) would have closed the circuit, with the central contact (*W*) energising solenoid No. 1 and moving the piston forward to the neutral position, where the circuit would be broken by contact (*P*) moving away from the central contact.

If high or low gear is selected with the gear in neutral, the circuit is direct from the selector contact (16) to solenoid No. 1. If second or reverse gear is selected with the gears in neutral, the circuit is direct from the selector contact (14) to solenoid No. 2.

If the gears are in high and low is selected, the circuit is direct from (11) on the selector to solenoid No. 3 to obtain the cross shift when neutral is reached.

The circuit from (12) on the selected switch will be to (2) and (4) on the interlock switch and then to the central contact (*W*) of the neutral switch. Since the gear is in high (piston forward) contact (*Q*) will close the circuit from the central contact to solenoid No. 2, and the gear will move to neutral, where the contact with the central contact (*W*) will be broken, the cross change will take place, turning the interlock switch so that the circuit is from (2) to (1) to the selector switch (13) and (16) to solenoid No. 1, and the change will be completed to low gear.

Had the gear been in second when low was selected, the contact (*P*) would have been closed with the central contact (*W*), so that solenoid No. 1 would have been energised bringing the transmission to neutral when the contact would have opened and the change made to low as before.

Electric Hand (1938 Models)

The changes in the electric hand for 1938 models embody two changes in switch operation and location, which eliminate their adjustment, and the addition of a gear-abutment indicator mechanism which gives the operator a reaction of actually feeling the gear engagement taking place in the gearbox when moving into low or reverse gear.

Fig. 14 shows the wiring diagram and components. Because of the extra electrical circuit for the control of the abutment indicator, a new upper and lower wiring harness and a new 10-prong connector jack are necessary.

DELCO-REMY COIL IGNITION

IGNITION COILS

THE purpose of the ignition coil is to transform energy from the low-voltage source (dynamo or battery) into energy at sufficiently high voltage to jump the gap at the sparking plug.

There are two electrical circuits within the coil, namely, the primary and the secondary (*see* Fig. 1). The primary is wound with comparatively few turns of heavy wire, usually on the outside of the secondary. Each end of the primary winding is connected to a low-tension terminal. The secondary is wound with many layers of fine wire around the iron core. Each layer is insulated from the adjacent layer. Most coils have one end of the secondary winding connected to the primary and the other end connected to the high-tension terminal.

When the contact points in the distributor close, current from the dynamo or battery flows through the primary circuit, creating a magnetic field about the windings and core. The current does not instantly reach its highest value, due to the inductive effect of the magnetic field. A definite time is, therefore, required for the field to "build-up." As the magnetic field is greatest when the current reaches its highest value, it is necessary that the coil and distributor be designed to allow sufficient "building-up" time to obtain adequate spark at the highest engine speed.

When the distributor contact points open, the current in the primary does not stop flowing instantly, but flows into the condenser, which is connected in parallel with the contacts. This action prevents arcing and assures a quick collapse of the magnetic field without the loss of energy through an arc at the contacts. The quick collapse of the magnetic field induces a voltage in the primary as well as the secondary windings. This voltage increases until it is sufficiently high in the secondary to produce a spark at the sparking

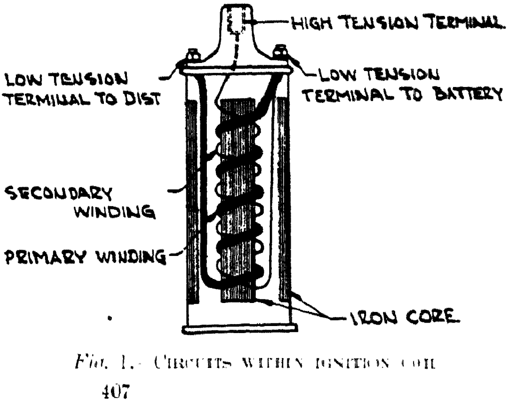


Fig. 1.—CIRCUITS WITHIN IGNITION COIL

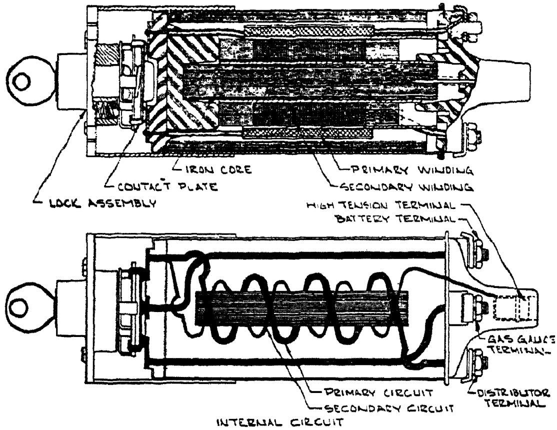


Fig. 2.—LOCK-TYPE COIL

plug. Since there are sixty to one hundred times as many turns in the secondary as there are in the primary, the induced voltage in the secondary will be sixty to one hundred times that of the primary. A secondary voltage is required to produce the spark at the plug. Variations in the amount of secondary voltage required are due to such factors as engine compression, engine speed, sparking-plug temperature, condition of the sparking-plug electrodes, and widths of the spark gap.

Types of Coil

The Delco-Remy ignition coils may be classified, according to the type of construction, as straight-ignition coils, lock coils, and switch-extension type coils. (*See* Figs. 1, 2, and 3.)

Standard ignition coils deliver adequate secondary energy to fire the engine under all conditions that are likely to be encountered. The standard universal service coils will replace most of the original equipment coils when the specified mounting brackets or adaptors are used.

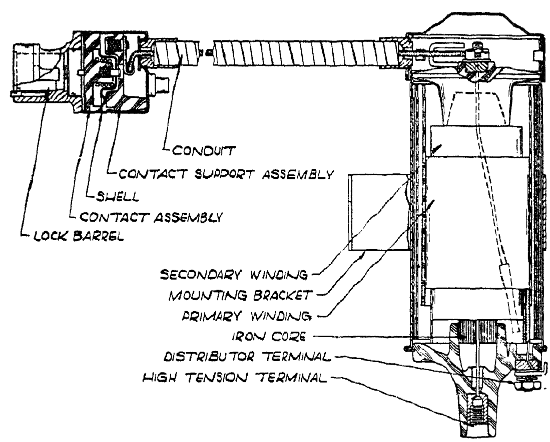


Fig. 3.—SWITCH-EXTENSION TYPE COIL

Special service coils are available which give maximum performance from low to the highest speeds. One

type is specially des for replacing either plain or switch-extension 6-volt coils. A resistance unit in series with the primary winding allows an increased current flow at high speeds for a given maximum at low speed. The resistance unit also permits the safe maximum current value (break ampères) to be used at low speed without excessive distributor-point oxidation when cold-weather or overcharged-battery conditions are encountered. The heavy-duty coils are more rugged in construction and are specially designed for continuous commercial vehicle and bus service.

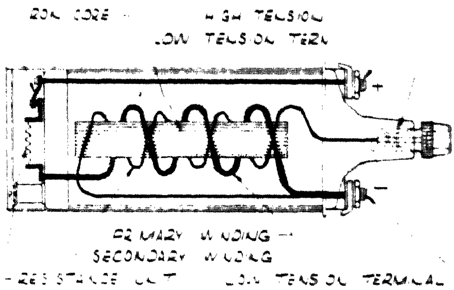


Fig. 4.—SPECIAL SERVICE COIL

Note the resis ance unit in series with the winding.

Service Instructions

Ignition coils do not require special service other than to keep all terminals and connections clean and tight. Coils having a resistance unit will not operate if the resistance unit is open-circuited. In case of failure in the windings, it is necessary to replace the complete coil.

The switch-extension type coils are designed to permit the removal of the coil without disturbing the ignition switch or switch extension. These coils are locked to the switch-extension assembly by means of the lock in the coil end cover which engages in the lock recess on the coil container. (*See* Fig. 5.) To remove the coil from the

it is necessary to remove the coil from its mounting, as shown in Fig. 5.

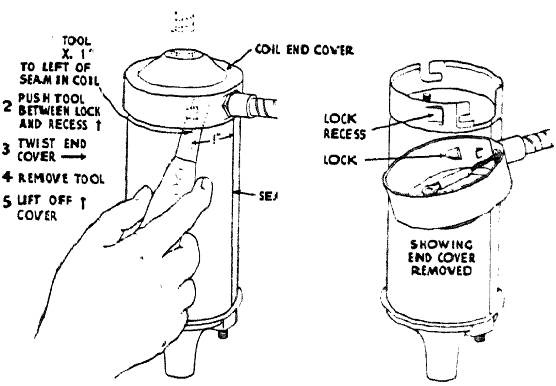


Fig. 5.—TAKING OFF END COVER OF SWITCH-EXTENSION TO PERMIT REMOVAL OF THE COIL

Ignition-coil Testing

If the coil does not fire the engine satisfactorily, the

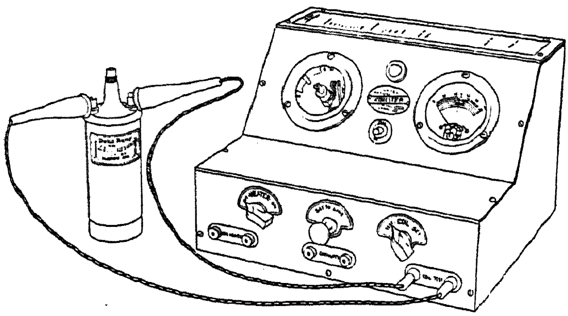


Fig. 6.—Coil under test with Koilster tester

unit should be removed from the car and checked. A lamp and test points may be used to detect open and earthed circuits. To test for an open primary circuit, hold a test point on each of the low-tension terminals of the coil. If the lamp fails to light, the primary circuit is open. To check the secondary circuit, hold one test point at the high-tension terminal and the other at one of the low-tension terminals. The lamp will not light, but tiny sparks will be noted at the point of contact if the winding is not open. If open, no sparks will occur.

Most coils used with single-wire systems can be tested for earthed windings by holding one test point on the metal container and touching the other point to the high- and low-tension terminals. If the lamp lights, or tiny sparks appear at the point of contact, the windings are earthed. This test does not apply to coils used with two-wire systems, as these coils have one end of the secondary winding fastened to the metal container.

Test Sets

There are various types of test stands used for testing ignition coils. Some test stands are equipped with a variable-speed motor together with a breaker mechanism and spark gap, so that the coil performance may be noted at different speeds. Other tests use a spark gap to compare the spark of the questionable coil with the spark delivered by a known good coil. In this case, both coils must be subjected to the same temperature conditions for comparison, and identical test leads must be used.

An approved coil tester, known as the Koilster, accurately distinguishes between a good and a bad coil. The coils are checked on the Koilster without making connection at the secondary terminal (*see* Fig. 6). This removes the variations, due to altitude, atmospheric or spark-plug-electrode conditions, usually found in the spark-gap type of test. This instrument indicates if the coil conforms with the manufacturer's specifications. Continuity tests for the primary and secondary can also be made.

The Koilster tests the coil both cold and hot. A heating circuit with an automatic time switch is provided to heat the coil to operating tem-

peratures. Readings on the meter must fall within the cold and hot limits specified for the particular coil.

Coil Defects as Indicated on the Koilster

The most common ignition-coil defects are indicated on the Koilster as follows :

(1) *Open-circuit Primary.*—Koilster shows no meter reading on coil test or primary continuity.

(2) *Open-circuit Secondary.*—Koilster shows no continuity on secondary.

(3) *Shorted Turns in either Primary or Secondary.*—Koilster indicates low reading outside of specification limits.

(4) *High-voltage Breakdown in Secondary.*—Koilster meter reading erratic. Pointer bobs in and out of limits.

(5) *High Resistance in Primary Connections.*—Koilster reading low.

CONDITIONS AFFECTING IGNITION PERFORMANCE

If the ignition performance is unsatisfactory after the coil has been tested and found to be good, it is necessary to look for trouble elsewhere in the ignition circuit.

(1) Resistance in Ignition Circuit

Energy is lost whenever resistance is present in a circuit. Oxidised, burned, or pitted distributor contacts offer resistance to the flow of primary current. A loose connection or poor earth at the condenser will cause faulty ignition. Connections at the battery, ammeter, coil, and ignition switch should be clean and tight.

(2) Poor Insulation in Ignition Circuit

Insulation in the ignition circuit is very important. The high-tension cables should not be oil-soaked, cracked, or punctured, as this will result in a loss of electrical energy. Examine the distributor cap for burned paths. If any of these conditions are present, the cables or distributor cap should be replaced.

(3) Defective Condenser

A condenser failure will cause complete failure of the ignition system. Condenser failures are due to punctured insulation, open circuits, high-resistance connections, and low-insulation resistance. The condenser should be checked on a precision instrument.

(4) Incorrect Sparking-plug Gap Setting

Sparking plugs should be cleaned when dirt, oil, and carbon are present. Replace the plugs if the points are badly burned or the porcelain cracked. The size of the gap largely determines the voltage required to

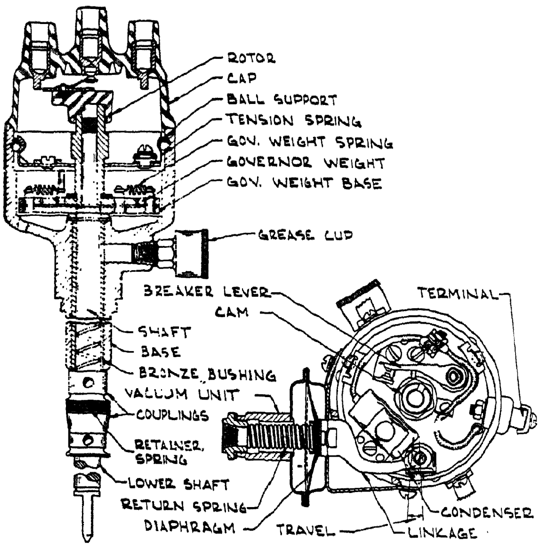


Fig. 7.—Typical Delco-Remy ignition distributor

fire the plug. A high-speed engine miss can sometimes be traced to a wide spark-plug gap. Set the plug gaps according to the manufacturer's specifications.

(5) Battery

The battery is an important factor, since it must furnish current to the coil to create the magnetic field. Be sure it is charged and in good condition. The battery terminals should not be dirty, loose, or corroded, because these conditions cause resistance in the circuit

(6) Arcing across Coil Terminals

When excessive moisture collects on the coil top, the high-tension spark will sometimes arc across to the low-tension terminals, causing the engine to miss. Continued arcing will eventually burn a path across the bakelite coil top. (Heavy-duty coils have an arc-resisting cap of special bakelite material that will not burn when the spark jumps across its surface.) In cases where arcing occurs, it is recommended that a

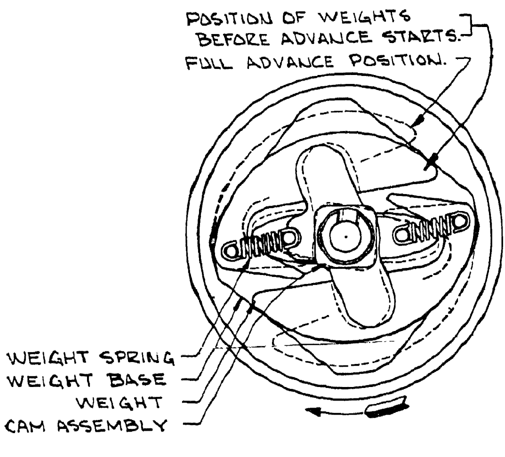


Fig. 8.—Centrifugal spark-control mechanism.

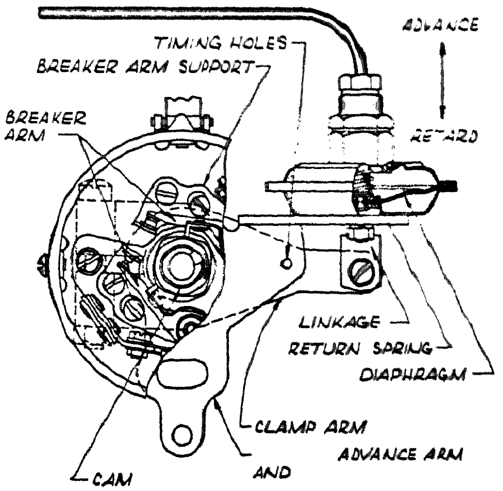


Fig. 9.—Vacuum control mounted on

Diaphragm linked to distributor housing so that advance and retard are secured by rotating the distributor in its mounting.

rubber nipple be used on the high-tension terminal. The rubber nipples may also be used on the high-tension terminals of the distributor cap, to eliminate arcing between the terminals.

DISTRIBUTORS

Spark Controls

Delco-Remy distributors have various types of spark advance control, as follows:

(1) Full manual.
(2) Centrifugal.
(3) Vacuum.

The manual control, which permits the driver to secure spark retard for starting, idling, and hard pulls, is rarely used to-day.

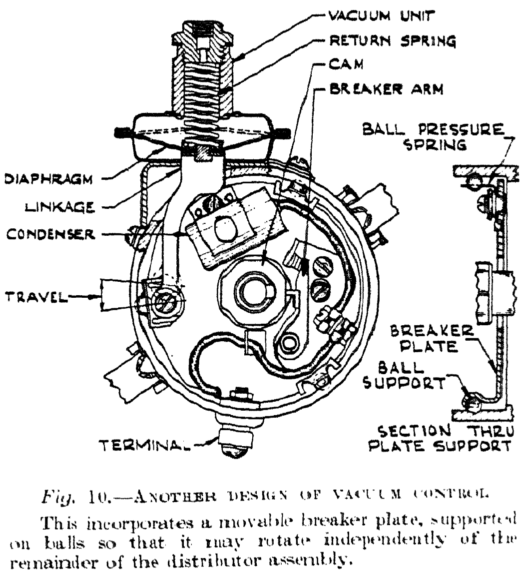


Fig. 10.—Another design of vacuum control.

This incorporates a movable breaker plate, supported on balls so that it may rotate independently of the remainder of the distributor assembly.

Centrifugal Control

Where speed variations are encountered, a spark advance based on engine speed is necessary to develop maximum power. Fig. 8 shows the centrifugal spark-control mechanism which operates to secure this advance. As engine speed increases, the weights gradually throw out and rotate the cam to give the desired spark ad-

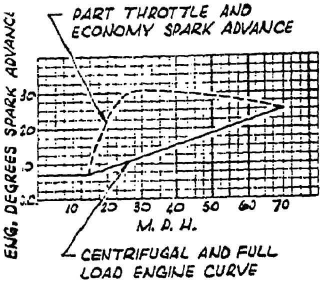


Fig. 11.—ADVANCE CURVE SECURED WHEN VACUUM IS TAKEN ON THE CARBURETTOR SIDE OF THE THROTTLE VALVE

vance for the speed at which the engine is running. The correct spark advance for an engine is determined by varying the advance with wide-open throttle, to find the point where maximum power develops. Weights, cam contour, and spring calibration to give this advance are then selected.

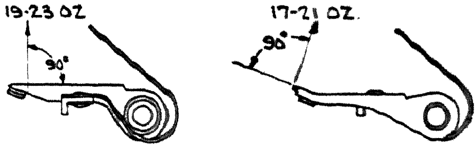
A combination of centrifugal and vacuum advance is used on many applications.

Vacuum Control

An engine operating under part throttle can have a spark advance in addition to the centrifugal advance without objectionable ping. The engine will perform satisfactorily with only a centrifugal advance, but with an additional advance obtained by a vacuum advance control, the engine will show greater petrol economy. The vacuum control consists essentially of a diaphragm and link acting against a spring. The vacuum control may be mounted on the engine, with the diaphragm linked to the distributor housing, so that advance and retard are secured by rotating the distributor in its mounting (Fig. 9). Another design incorporates a movable breaker plate, supported on balls so that it may rotate independently of the remainder of the distributor assembly (Fig. 10). A variation of this design uses a double-race ball bearing to support the breaker plate on the camshaft. The diaphragm of this type unit is linked to the breaker plate, and the plate rotated to secure the vacuum control of the spark advance.

Fig. 11 illustrates the advance curve secured when the vacuum is taken on the carburettor side of the throttle valve. This is the most commonly used application. The solid line is the centrifugal and full-load engine curve resulting from the centrifugal action. When the throttle is closed, there is no vacuum in the carburettor and no vacuum spark advance. The vacuum tube from the vacuum control enters the carburettor throat just back of the throttle butterfly. As soon as the throttle is opened, the manifold vacuum is admitted to the carburettor and the vacuum control, producing an advance, shown dotted, which is in addition to and independent of the centrifugal advance. At higher speeds and with open throttle, the vacuum diminishes and the vacuum spark advance drops off. With wide-open throttle at any speed there is no vacuum advance, all advance under that condition being based on the centrifugal action.

DISTRIBUTOR MAINTENANCE



12. MEASUREMENT OF CONTACT-POINT SURE

Lubrication

All bearings with hinge-cap oilers should have eight to ten drops of light engine oil every 1,000 miles. Distributors with bronze or grey-iron bearings and grease-cups should have the grease-cups kept filled with medium cup grease and turned down one turn every 500 miles. With ball bearings, keep the grease-cup filled with ball-bearing grease, and turn down one turn every 1,000 miles. Distributors with high-pressure lubricating connections should be lubricated every 1,000 miles. Apply a small amount of vaseline to the breaker cam when lubricating the distributor. On the vacuum-type distributor with the breaker plate supported by three balls, the balls and race should be lubricated with light engine oil every 5,000 miles. Avoid excessive lubrication.

Inspection

The cap should be removed at regular intervals and the contact points, rotor, and cap examined. Check the high-tension wiring for grazed or damaged insulation and poor connections at the cap or plugs. Replace if necessary. Replace the cap or rotor if they are cracked or show carbonised paths, indicating the secondary current is leaking to earth over the surface of the bakelite.

Contact Points

Contact points that are burned or pitted should be replaced or dressed with a clean, fine-cut contact file. The file should not be used on other metals, and should not be allowed to become greasy or dirty. Never use emery cloth to clean contact points. Contact surfaces, after considerable use, may not appear bright and smooth, but this is not necessarily an indication that they are not functioning satisfactorily.

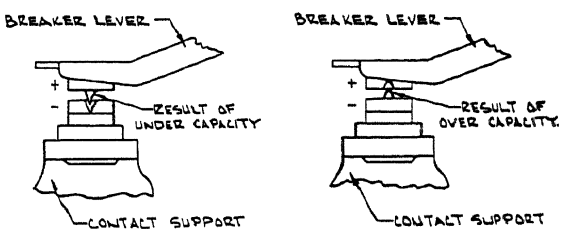


Fig. PITTED CONTACT POINTS CAUSED BY DENSER WITH INCORRECT CAPACITY

Oxidised Contact Points

These may be caused by high resistance or loose connections in the condenser circuit, oil or foreign materials on the contact surfaces, or, most commonly, high

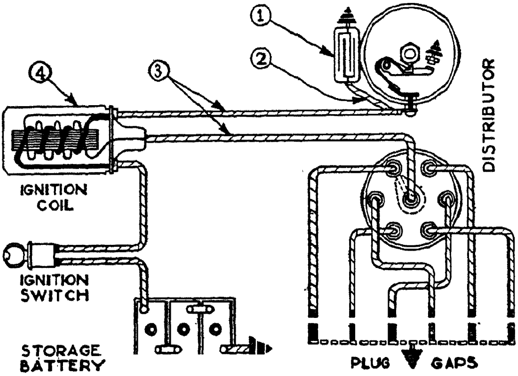


Fig. 14.—A TYPICAL IGNITION CIRCUIT AND THE VARIOUS CHANGES WHICH CAN BE MADE TO CORRECT POINT-PITTING TROUBLE

For an explanation, see text.

voltages. Check for these conditions where burned contacts are experienced.

The Contact-point Opening

This must be set to the proper limits. Points set too closely may tend to burn and pit rapidly. Points with excessive separation tend to cause a weak spark at high speed. The point opening of new points may be checked with a feeler gauge. A feeler gauge is not so accurate on used points, owing to the roughness of used points. A dial indicator or a contact angle-meter for checking the point opening of used points is more accurate.

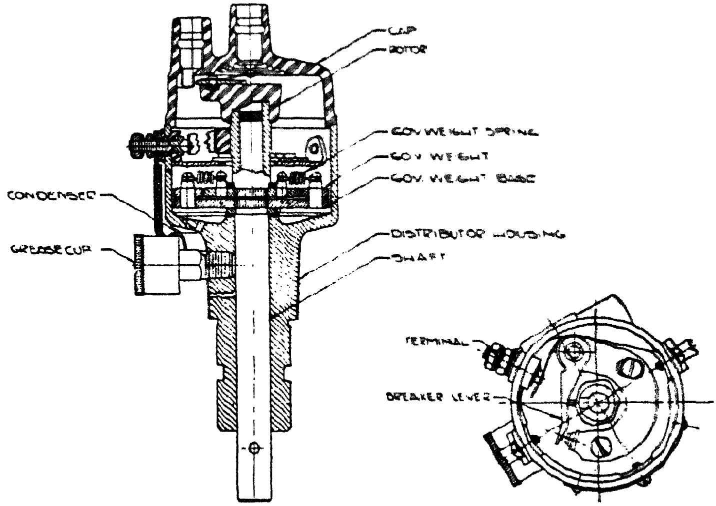
The cam or contact angle is the angle in degrees of cam rotation through which the points remain closed. This angle increases with decreased point opening. As the rubbing block of a new breaker arm wears in, rounding the corners of the rubbing surface, the contact angle increases. Therefore, with a new arm, set the contact angle about 3° less than with an arm worn by several thousand miles of operation. The angle given in the test specifications is subject to a variation of 2° plus or minus, depending on these conditions.

Contact-point Pressure

This should be measured as shown in Fig. 12, and must fall within the limits given. Weak tension will cause point chatter and ignition miss at high speed, while excessive tension will cause undue wear of the contact points, cam, and rubbing block.

Timing and Synchronisation

Most cars have flywheel markings to facilitate timing the distributor to the engine. Due to individual differences in engines, the timing instructions supplied by the engine manufacturers should be followed. All ignition distributors with manually controlled spark should be timed in the full manual advanced position to eliminate variations in the manual-control linkage. Some distributors having vacuum-controlled spark have a $\frac{1}{8}$-in. hole in the advance arm and clamp arm. On these cars it is necessary to align the holes with a $\frac{1}{8}$-in. pin before timing.



ig. 15.—SMALL-TYPE BRITISH-MADE DELCO-REMY IGNITION DISTRIBUTOR MADE IN BOTH FOUR- AND SIX-CYLINDER MODELS, WITH CENTRIFUGAL AUTOMATIC SPARK ADVANCE

in conjunction with manual and/or vacuum control. Suitable for engines with maximum speed 5,000 r.p.m. to 6,000 r.p.m.

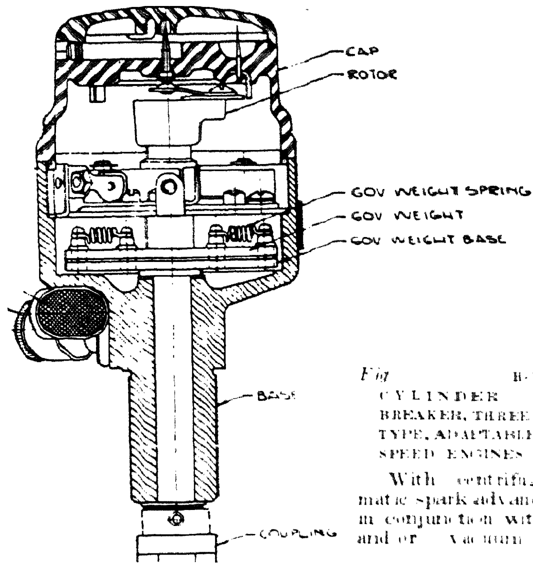


Fig ...H-MADE SIX-CYLINDER DOUBLE BREAKER, THREE-LOBE CAM TYPE, ADAPTABLE TO HIGH-SPEED ENGINES

With centrifugal automatic spark advance. Used in conjunction with manual and/or vacuum control.

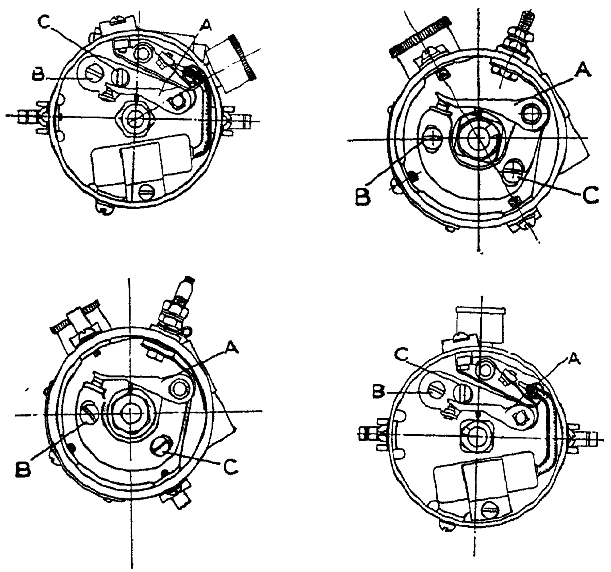


Fig. 17.—British-made Delco-Remy distributors having single breaker arm

The only adjustment required in service is to ensure that the contact gap opening is correct, namely, ·018 in. to ·024 in., as described in the text.

On some engines it is not possible to synchronise double breaker lever distributors on the engine without special synchronising tools. This is particularly true on twelve- and sixteen-cylinder engines. Methods of synchronising are dealt with later for British-made distributors.

Use of Synchroscope

The synchroscope accurately checks cam angle, spark advance, and synchronisation on distributors removed from the car. It will also show excessive distributor-shaft eccentricity as indicated by variation in synchronisation.

After a distributor has been repaired, the calibration of the centrifugal automatic mechanism should be checked. Proper engine performance cannot be obtained unless the centrifugal curve is within the limits specified for the particular engine.

The Vacuum Unit

An instrument capable of measuring the vacuum in inches of mercury is required to check the vacuum unit. The amount of vacuum necessary to start the plunger and the amount of vacuum necessary to get complete plunger travel should be checked. If it is found that the unit is not performing according to specifications but that the variation is not great, the spring in the unit may be recalibrated by stretching. If this does not

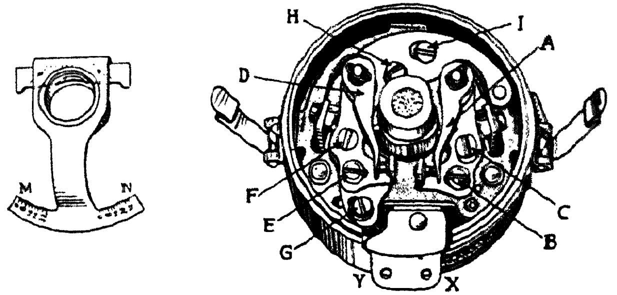


Fig. 18.—EIGHT-CYLINDER DISTRIBUTOR SYNCHRONISATION

correct the fault the spring should be replaced. If the vacuum is leaking it will be necessary to replace the unit.

The Condenser

Four factors affect condenser performance, and each factor must be considered in making any condenser tests.

Breakdown is a failure of the insulating material, a direct short between the metallic elements of the condenser. This prevents any condenser action.

Low-insulation Resistance or leakage prevents the condenser from holding a charge. A condenser with low insulation resistance is said to be " weak." All condensers are subject to leakage, which up to a certain limit is not objectionable. When it is considered that the ignition condenser performs its function in approximately 1/12,000 of a second, it can be seen that leakage can be large without detrimental effects. It must be considered, however, in any condenser test.

High-series Resistance is excessive resistance in the condenser circuit due to broken strands in the condenser lead or to defective connections. This will cause burned contact points and ignition failure upon initial start and at high speeds.

Capacity is built into the condenser and is determined by the area of the metallic elements and the insulating and impregnating materials. A low-capacity condenser is suitable for an operation where high speeds predominate, while a higher capacity condenser is desirable for low-speed operation. Incorrect capacity for the type of operation will result in point pitting (Fig. 13). The direction of the pit and the build-up can be used as a basis for analysis and correction of the condition. If the build-up is on the positive side, the condenser may be under capacity. If the build-up is on the negative side, the condenser may be over capacity.

Another factor which may affect point pitting is the position of the primary and secondary leads with respect to each other and to ground. Incorrect location may result in point pitting.

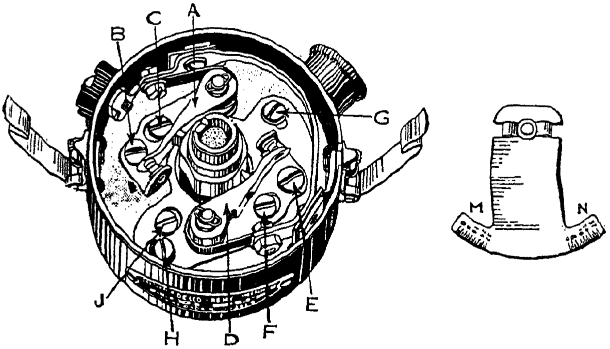


Fig. 19.—SIX-CYLINDER DISTRIBUTOR SYNCHRONISATION

Fig. 14 illustrates a typical ignition circuit, and the various changes which can be made to correct point-pitting trouble.

With the build-up of material on the positive point (pitting of the negative), the following changes tend to be corrective:

(1) Increasing condenser capacity.

(2) Shortening condenser lead.

(3) Separating the low- and high-tension coil distributor leads. Moving leads closer to earth (engine block, frame, panels, etc.).

(4) Mounting coil directly to earth if it is not so mounted.

With the build-up of materials on the negative point (pitting of the positive) the reverse of the above changes tend to be corrective.

British-made Delco-Remy Distributors

Figs. 15 and 16 show the details of construction of typical British-made Delco-Remy distributors. When vacuum control is incorporated, the arrangements are similar to those shown in Figs. 9 and 10.

Information as to adjustment of British-made Delco-Remy distributors is given below.

Adjustment of British-made Distributors having Single Contact Breaker

These are the most simple types of distributors having a single breaker arm (*see* Fig. 17). A four-lobe cam is fitted to the four-cylinder type and a six-lobe cam to the six-cylinder type.

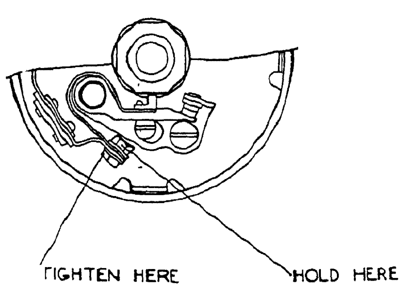


Fig. 20.—WHEN FITTING NEW CONTACT ARM

Take care, when tightening the point spring, that there is no binding. Binding of the spring can be relieved by tightening, as shown above.

The only adjustment required in service is to ensure that the contact-gap opening is correct, namely ·018 in. to ·024 in. To adjust the points, turn the shaft till the rubbing block of the breaker arm *A* (Fig. 17) is on a lobe of the cam. Loosen screw *B* and turn screw *C* until the gap between the two points is correct. Do not omit to tighten screw *B* after this operation.

Synchronising Six-cylinder Three-lobe and Eight-cylinder Four-lobe Cam Distributors having Double Breaker

On this type of ignition distributor, the two contact arms form parallel circuits for the ignition current, and the circuit through the coil is not broken till both sets of contact points are open.

One-half of the cylinders are fired by each set of points. On the eight-cylinder distributor with four-lobe cam, the points must open 45 cam degrees apart, and on the six-cylinder type with the three-lobe cam, 60 cam degrees apart. If the points do not open at this interval, one half of the cylinders will have a different ignition timing from the other half. To get this very important adjustment, the instructions given below must be carried out carefully, and a tool is required as illustrated in Fig. 18, which can be obtained at an authorised Delco-Remy service station.

To Synchronise Circuit-breaker Opening on Delco-Remy Distributors with Four-lobe Cam

One set of contact points is stationary and the other set is movable. The stationary set is adjusted first and the synchronising is completed by adjustments to the movable set of points.

To set contact opening of arm *A* (*see* Fig. 18), turn distributor shaft in its direction of rotation until rubbing block of breaker arm *A* is on lobe of cam. Loosen screw *B* and turn screw *C* to get contact opening, which is ·018 in. to ·024 in., preferably ·022 in. Tighten screw *B*.

Again turn the shaft till rubbing block of breaker arm *D* is on the lobe of cam. Loosen screw *E*, turn screw *F* till points open between ·018 in. and ·024 in., preferably ·022 in. Tighten screw *E*.

Put synchronising tool over cam, locking it with slide pushed through, until it shows the arrow that points in the direction the shaft rotates, as viewed from the top. If rotation is clockwise viewed from the top, turn shaft in this direction till breaker arm *A* breaks contact. Note marking on *M* side of synchronising tool that is in line with point *X*, which is the edge of the slot in the distributor-base rim. Continue to turn shaft till the same marking on *N* side of tool is in line with point *X*. Loosen screws *G* and *H* and turn screw *I* until arm *D* breaks contact. Check this by rotating shaft again. Tighten screws *G* and *H*. Also check contact opening of breaker arm *D*, and if it was set before at ·022 in., it should still be within the limits mentioned above. If outside of these

limits, reset the point opening and synchronise arms again. Do not make any adjustments to arm *A*, but confine the adjustments to arm *D*, to complete the synchronising.

For distributors having opposite rotation, proceed as directed, except rotation, and align with the *N* side of the synchronising tool first and the *M* side last.

The graduations on the tool represent engine degrees, and the breaker arm must not be out of synchronism more than two engine degrees.

The eye cannot detect the moment the points open. To get an accurate synchronising adjustment connect an ammeter in the ignition circuit at the distributor terminal. If on the car, make sure the ignition switch is "on." The instant the ammeter needle drops back to zero the points are open.

To Synchronise Circuit-breaker Opening on Delco-Remy Six-cylinder Distributor with Three-lobe Cam

The contact-point opening of the stationary breaker arm *A* (Fig. 19) should be set first, and then the synchronism completed by adjustments to the movable set of points (arm *D*).

Turn the distributor shaft till the rubbing block of breaker arm *A* is on a lobe of the cam. Loosen screw *B*, and turn screw *C* to get contact opening, which is from ·018 in. to ·024 in. Tighten screw *B*.

Turn shaft again till the rubbing block of breaker arm *D* is on the lobe of the cam. Loosen screw *E* and turn screw *F* till the points open ·018 in. to ·024 in., preferably ·022 in. Tighten screw *E*.

If the distributor rotates clockwise, viewed from the top, place synchronising tool on cam, with the *M* side of the spring in the slot in the cam, then turn cam in direction of rotation till the graduations on the *M* side of the tool are near the slot in the rim of the distributor base.

Continue to turn cam till breaker arm *A* breaks contact, and note graduation on tool that aligns with the approaching edge of the slot. Again turn cam, in same direction, till the same graduation on the *N* side aligns with the same edge. Loosen screws *G* and *H* and turn screw *J* till breaker arm *D* just breaks contact.

Check this by rotating cam again. Tighten screws *G* and *H*. Also check contact opening of lever *D*, and if it was set before at ·022 in., it should still be within the limits. If outside, reset the point opening and synchronise arms again, confirming the adjustments to the arm *D*.

For distributors rotating counter-clockwise, viewed from the top, the procedure is as described, turning the cam in a counter-clockwise direction and locating the side of the tool marked *N* in the cam slot.

The graduations on the tool represent engine degrees, and the *M* side is just 60 cam degrees or 120 engine degrees from like graduations on the *N* side. The breaker arms must not be out of synchronism more than 2 engine degrees.

The eye cannot detect the moment the points open. To get an accurate synchronising adjustment, connect an ammeter in the ignition circuit at the distributor terminal. If on the car, make sure the ignition switch is "on." The instant the ammeter drops back to zero the points are open.

Adjustment and Cleaning of Circuit-breaker Contacts

The correct gap for the circuit-breaker points is ·018 in. to ·024 in. It is important that this setting be checked and maintained. If the points are too closely set, rapid burning will result. The general cause of these points closing up is wear of the fibre heel on the contact arm and which bears on the cam. This wear can be minimised by lightly greasing the cam with vaseline. The only adjustment required in service is to maintain the correct gap as above.

When fitting a new contact arm be sure it is free on its pivot. A trace of light oil should be applied to the pivot, and care taken, when tightening the point spring, that there is no binding. Binding of the spring can be relieved by tightening the nut, as shown in Fig. 20.

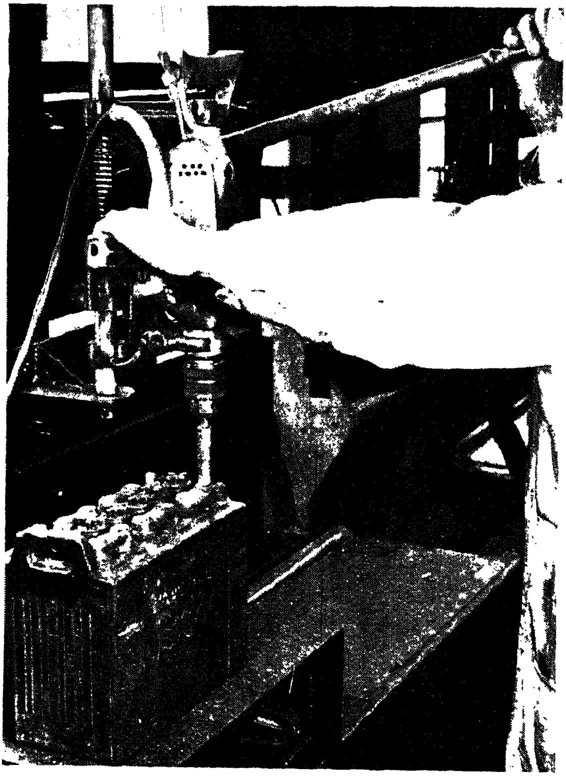
Should the contacts require cleaning, they should be lightly rubbed with an oil-stone until all raised portions of metal are removed. It is not necessary to grind the points away sufficiently to remove each small pit. Avoid oil on the points.

We are indebted to Messrs. Delco-Remy and Hyatt, Ltd., of 111, Grosvenor Road, London, S.W.1, for the information upon which the above article is based.

BATTERY REPLATING PROCEDURE AND SERVICING

By E. T. LAWSON HELME

THE battery, being the unit of car electrical equipment upon which all the others depend, must function with reliability under varying conditions of load and temperature. Modern design has produced very efficient batteries, and breakdown can nearly always be traced to neglect or normal deterioration.



ig. 1.—FIRST OPERATION IN PREPARATION FOR BATTERY REPLATING

Drilling out cell connectors. (*By courtesy of Shaw & ilburn, Ltd.*)

First Sign of a Defective Battery

The first sign of defectiveness is failure of cells to maintain voltage under load, or to remain in a fully charged state under no-load conditions. The reason is lost capacity, the result of several possible causes. Chief among these may be mentioned excessive sulphation of the elements through incorrect charging or neglect to maintain the level of the electrolyte, buckling of the lead

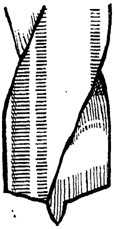


Fig. 1A.—SHAPE OF DRILL FOR LINK REMOVAL

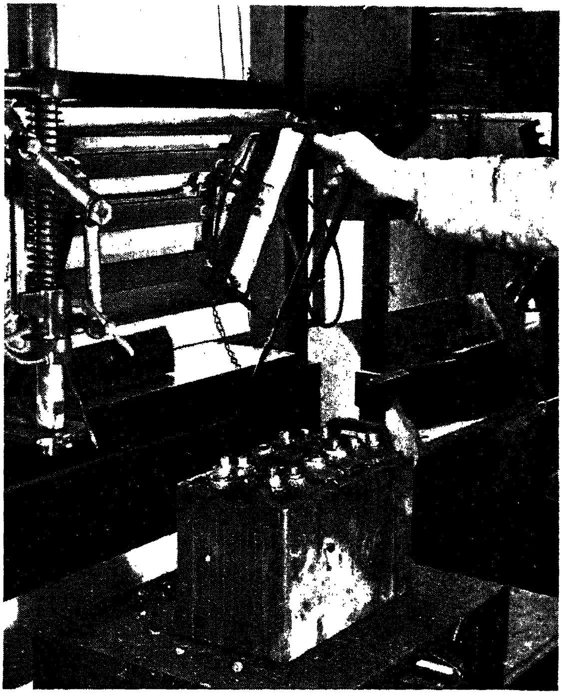


Fig. 2.—REMAKING BATTERY—SECOND OPERATION

When all the connections are removed, the pitch sealing top of plates is heated to soften for plate removal. Operation shows heater unit being brought into position. (*By courtesy of Shaw & Kilburn, Ltd.*)

grids, and dislodging of the active material, or the breakdown of the separator insulation —caused by high charge and discharge rates proportionate to normal capacity— or a defective container with leakage in the intercell partitions.

Finding Out Condition of Battery

The only reliable measure of cell condition is a combination of voltage readings on charge and discharge with a test of electrolyte density by a hydrometer syringe.

Specific Gravity Test

In the average starter battery, each cell should show the same specific gravity—1·250–1·280, and voltage should not fall below 1·8 volts per cell under starter load.

Volt Test

The loaded voltmeter used in most service depots for cell testing imposes a load of 150–180 amps—when cell voltage should read 1·2–1·4 volts if the battery is in sound condition. If one or more cells show a markedly lower reading, or fade away rapidly under 20–30 seconds'

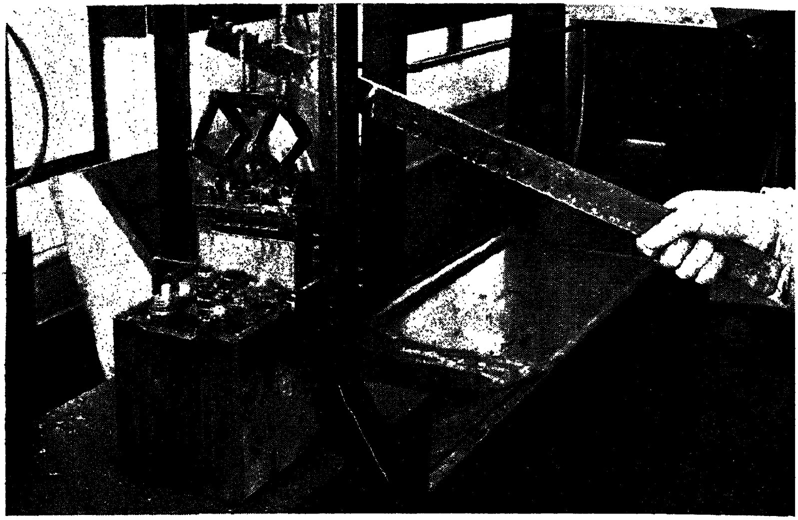


Fig. 3.—THIRD OPERATION

Plate removal. A special clamp lever is shown with one cell partly removed.

duration of load, the elements are defective and the battery must be opened up for inspection and repair.

Replating

It must be stressed at the outset that replating single cells in a battery is inadvisable, as the remaining cells have all had the same length of service and shared any ill-treatment which has been a contributory cause of trouble, so it is only logical to conclude that all need the same treatment, though only one shows signs of breakdown at the moment. If passed, the other cells will fail within a short time, and the work will have to be repeated on them. A complete replatal is the only reliable means of restoring battery condition.

Inspection Before Opening up Battery

Before opening up, the battery should be washed down, emptied of electrolyte, and inspected for evidence of damage, such as worn-away corners of the moulded container where a leak is liable to occur, broken fixing lugs, or cracks. A note should be made of any numbers or markings stamped on the inter-cell links.

Taking Off Links Between Cells

The inter-cell links are welded or " lead-burnt " to the cell terminal posts, and must be drilled off as shown in Fig. 1. The drill must be

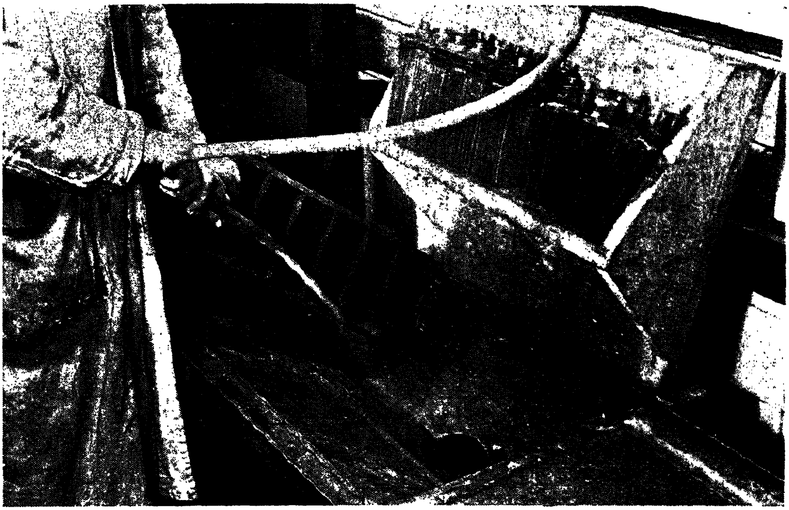


Fig. 4.—FOURTH OPERATION
When all the plates have been removed, casing is thoroughly drained and washed out.

started centrally and the drilling should extend only to about two-thirds the depth of the link. The drill should be about $\frac{5}{8}$-in. diameter, and should be ground with a pointed centre and a wide angle, as shown in Fig. 1A. The use of an electric bench-drilling machine enables the links to be drilled off centrally without centre-punching, though this may be advisable with the use of a portable hand drill.

Next Test for Leakage in Container

If the top of the battery is now wiped clean and dry, the cells may be tested for inter-cell partition leakage by applying prods from a mains-test lamp circuit to adjacent cell terminals, when the lighting of the lamp indicates leakage and the need of a new container. This is advisable when the owner asks for report and estimate of cost.

Removing the Cells

After removal of links, the sealing nuts should be removed, where fitted, and the battery placed under the heater for softening of the sealing compound. The unit shown (Fig. 2) is in the form of a swivelling cowl, with electric heating elements which radiate heat uniformly over cell lids, compound, and container edges. When the compound is soft to the consistency of butter, the cell units are ready for withdrawal.

Each cell group is extracted from its container by attaching claws to each terminal post and exerting even upward pull without straining one

side more than another. As the lid, which is a brittle, moulded pressing, must be pulled out with the group, it is necessary to ensure that the sealing compound is uniformly heated and softened throughout before attempting to lift the group.

In some designs, where the sealing space is deep, it is a good policy to remove as much as possible of the sealing compound with a hot putty knife and to run a thin hot knife blade round the lid to break its joint to the sides of the container.

Fig. 3 illustrates the extraction of groups with a specially designed tool which exerts a balanced pull, while the battery container is held in position by edge-plates.

An alternative method of preheating is the use of a steam chest, which takes the form of a box structure designed to lie on, and completely enclose, the whole top of the battery. A flexible pipe connects this chest to a steam generator, and the steam permeates each cell through the filler orifice, heating the internal lid surfaces and cell walls, preparatory to group extraction. Whichever method is used, it should be borne in mind that the crates and lids of modern batteries are of a material which softens with heat, so that care is necessary to avoid distortion or damage.

Washing Lids and Containers

When the cell units are out, the lids, if intact and fit for further use, should be removed, cleaned of compound, washed, and put aside while

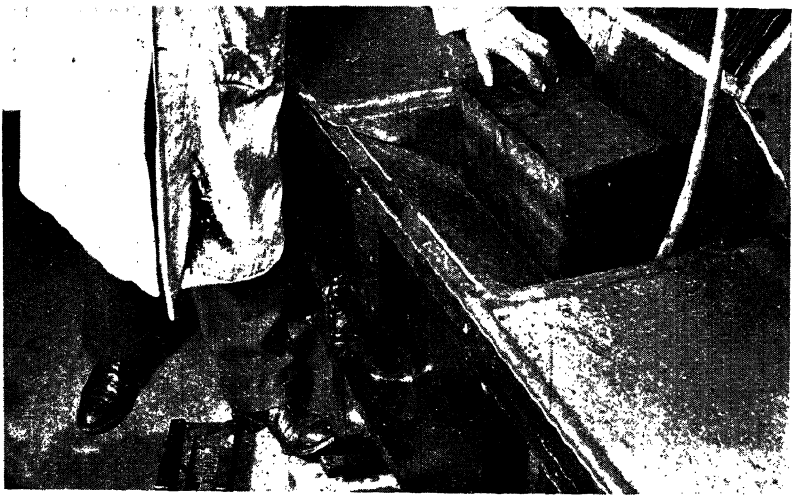


Fig. 5.—WASHING OUT (

High-pressure jet of water is being directed to inside of container. Inverted container over jet, which is being operated by foot.

still warm. They should be inspected for damage, distortion, cracks, or other defects, while the stoppers should be washed and replaced while the lids are semi-plastic to ensure that the filler orifices do not lose shape when cool and hard.

The acid residue in the containers and on the plates needs to be treated with respect, as its corrosive possibilities are far-reaching.

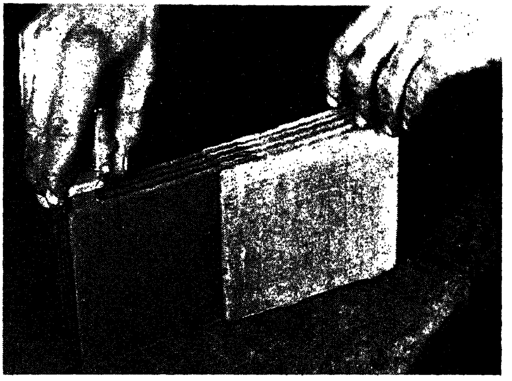


Fig. 6.—ASSEMBLING NEW PLATES

Positive and negative plate groups of a battery cell being correctly interleaved together. Note that negative plate occupies outside position on each side of the groups.

Wet plates should be handled only through rubber gloves or hands treated with neutralising ointment, and should be placed on a rack or lead-covered drain-board

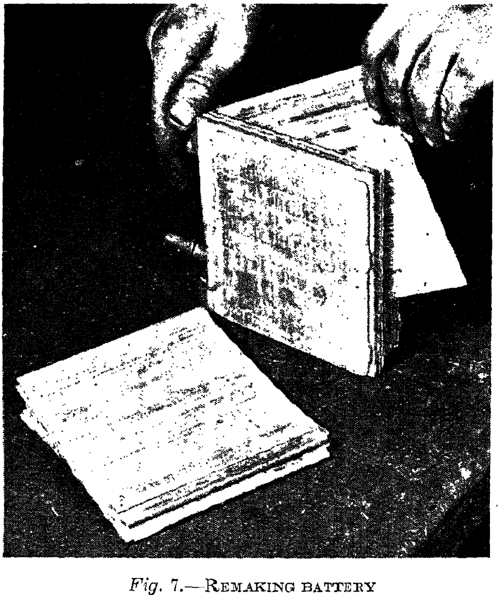


Fig. 7.—REMAKING BATTERY

This shows the thin wooden separators being inserted between the positive and negative plates of a battery cell.

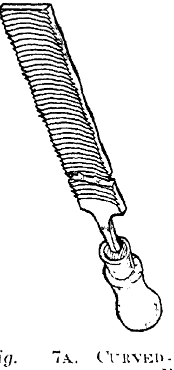


Fig. 7A. CURVED-TOOTH "FLOAT" FOR LEAD WORKING

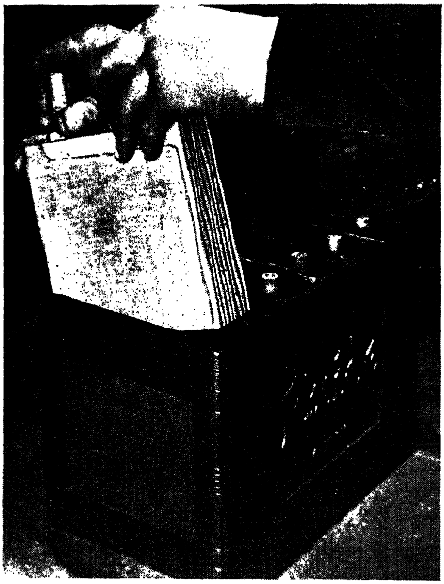


Fig. 8.—REMAKING BATTERY

The new groups of plates and separators being inserted into battery case.

while the container is thoroughly washed out. Fig. 4 shows this operation, in which a powerful water jet is employed to dislodge caked sediment.

The appliances used for washing out containers must include means of preventing the sediment, which is washed out in suspension, entering main outlets in such proportion as to cause a stoppage. The usual method is a trap tank with outlet pipe near its upper edge so that the sediment, composed of dislodged lead oxide and chemical waste, collects in the tank, and only a small percentage is carried out with the water. Fig. 5 shows a method used to dislodge hard accumulations between the ribs at the bottom of each cell container. This space must be properly cleared, so that sheddings from the plates will not form a conducting layer liable to short-circuit positive and negative elements.

The sediment tank, situated beneath the V-shaped sink shown in the photograph, has a main water pipe sealed into its bottom and projecting upwards with a nozzle extremity. A spring-loaded valve, operated by pedal, enables a strong jet to be directed into each container when the crate is inverted over it.

Examining the Cell Plates—Faults and Their Causes

Examination of the cell elements removed will usually reveal the causes of failure and may serve to indicate the line of advice to the owner, or treatment of the vehicle electrical equipment where there is reason to assume that battery breakdown is the result of defects in it.

Spongy Plates

When the plates—especially the positive groups—are found to be spongy with loosened active material, and the lead grids or plate frames are buckled, this may be traced to excessively high charging and dis-

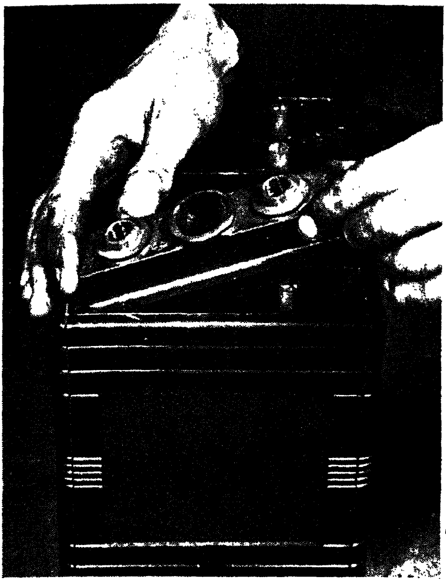


Fig. 9.—FITTING THE COVER TO THE CELL AFTER INSERTING THE GROUPS

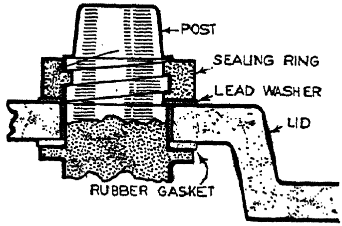


Fig. 9A.—RING SEAL OF POST

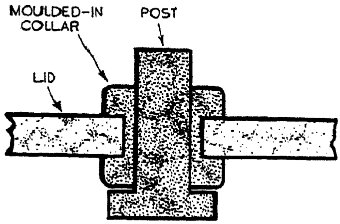


Fig. 9B.—COLLAR SEAL OF POST

charging rates, indicating the need for correction of dynamo and charging control or the reduction of load.

Sulphated Plates

Light-brown positive plates with hard brittle surfaces, and negative plates of hardened texture and white patches, indicate excessive formation of lead sulphate, usually due to prolonged idleness in a discharged condition, or insufficient charging hours to maintain the balance of discharge.

Shorted Plates

A cell which gave no reading on the cell voltmeter may be found to be shorted by a fragment of lead joining group bridges. Accumulation of sediment, or punctured separator. The latter will nearly always be due to heating and plate buckling, or may be occasioned by the omission of a separator on the previous assembly.

Open-circuited Plates

As an open circuit will cause no reading, in addition to disabling the battery entirely, cause should be sought in broken group straps, terminal

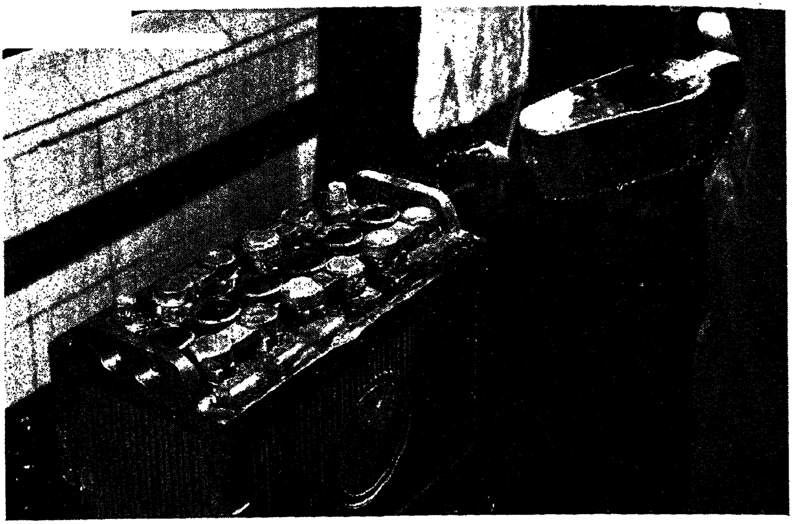


Fig. 10.—REMAKING BATTERY
Sealing the covers with pitch.

post, or similar defect. Hardening and sulphation—indicated by a white surface deposit—on the upper halves of both elements is a clear indication of elements exposed by failure to maintain correct level of electrolyte.

The crate should also be examined for cracked inter-cell partitions, caused by overheating and expansion of elements.

Assembling New Groups

With container dried and checked, lids and stoppers cleaned, nuts and inter-cell links renewed or restored for further use, the new groups can be assembled. Fig. 6 shows positive and negative groups being correctly interleaved together. Note that plates must be in alternate positions, and that there is one more plate in the negative than in the positive group.

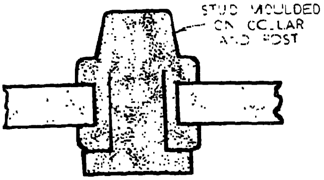


Fig. 10A.—SHAPE OF FINISHED STUD

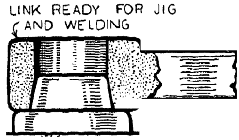


Fig. 10B.—ASSEMBLY OF LINK READY FOR WELDING

A negative plate, therefore, occupies outside position on each side. The groups should be assembled with edges level and the lid tried on to make sure that the terminal spacing is correct. This being so, separators can be inserted.

Fig. 11.—FITTING JIGS PRIOR TO WELDING CELL CONNECTORS

Inserting the Separators

There seems to be a variation of opinion as to whether the grooved sides of wood separators should be towards the positive or the negative plates. New groups should be assembled in the same way, in this respect, as those removed from containers. It is most important to ensure that no separators are omitted. The number required should be placed in a pile and used in assembling, and each group should be checked on completion. The group elements, being interleaved, are laid on one side, and the separators inserted from the uppermost side and bottom of the group, as depicted in Fig. 7. A practice which experience has proved sound is to commence with the

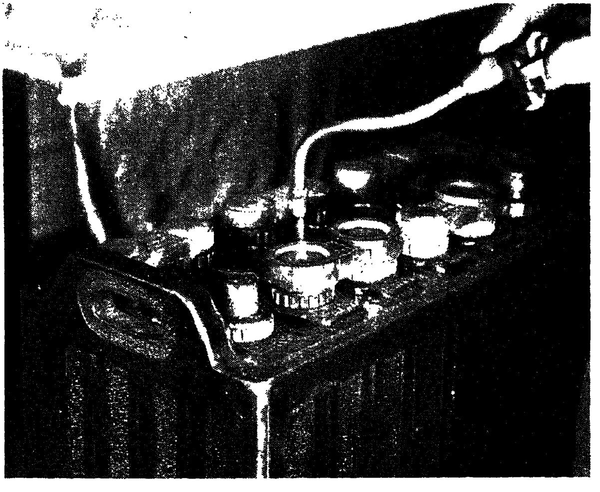


Fig. 12.—WELDING CELL CONNECTORS

The operator looks through glass screen of fume extractor (*see* g. 13).

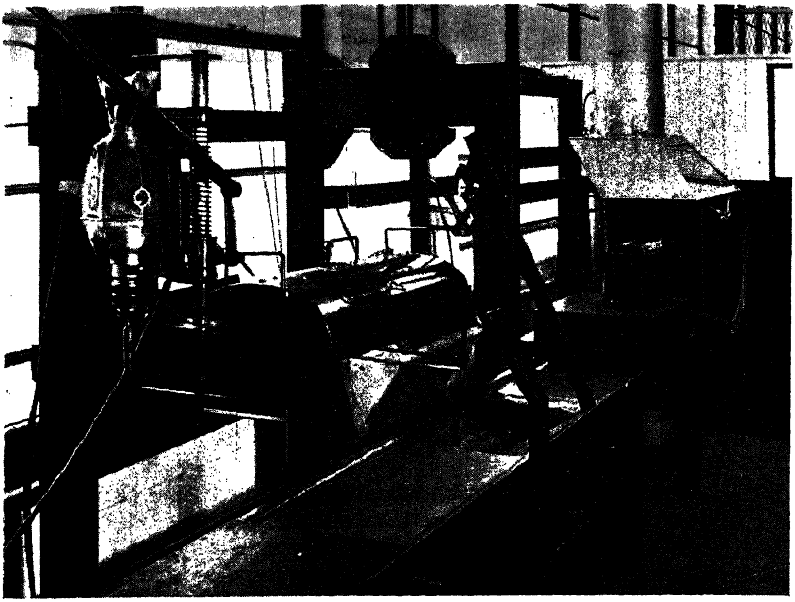


Fig. 13.—GENERAL VIEW OF REPLATING PLANT

The fume extractor can be seen at the right. (*By courtesy of Shaw & Kilburn Ltd.*)

middle pair and work outwards alternatively, making sure that grooved sides are correctly positioned. If the outer separators do not slide easily into place, they can be gently tapped in with a wooden bat, tapping the side of the separator which is cut across the grain. Edges should be levelled up and the group stood on a clean board or sheet of paper to avoid dirt or chippings of lead becoming lodged between plates. It should be remembered that separators must always be kept in the air-tight wrappings in which they are packed. If left out in the atmosphere, they soon dry and warp, and are rendered useless.

Before commencing to assemble the groups into the container, the inside edges of compartments should be freed of any remaining sealing by paring with a sharp knife, paying special attention to corners. This enables lids to be easily refitted, and risk of breakage is minimised.

Repairing Containers

Cracked containers or partitions cannot be successfully repaired, but small blemishes or worn corners may be restored in moulded containers if the damage is slight. The moulded material is softened by a gentle gas flame, using the lead-burner with no oxygen, when a piece of broken lid of the same material is worked into a putty consistency with the flame

and a hot knife, and pressed into the damaged part, being kept plastic and smoothed off, allowing time for subsequent cooling and hardening. A tool of considerable use to battery men is the "curved-tooth float"—sketched in Fig. 7A—resembling a file in shape, but cut with coarse cutting edges across its faces. This tool will work lead without clogging and can be used with advantage to smooth off the repair to the moulded crate when hard. The top edges of container may also be smoothed off if rough or damaged.

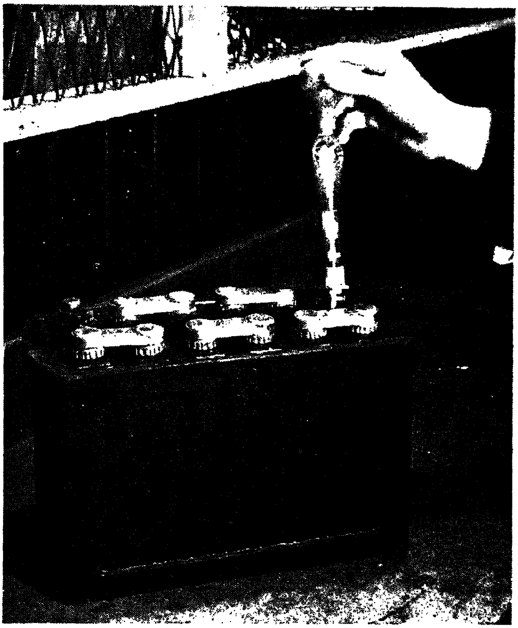


Fig. 14.—HYDROMETER TEST FOR SPECIFIC GRAVITY OF ACID

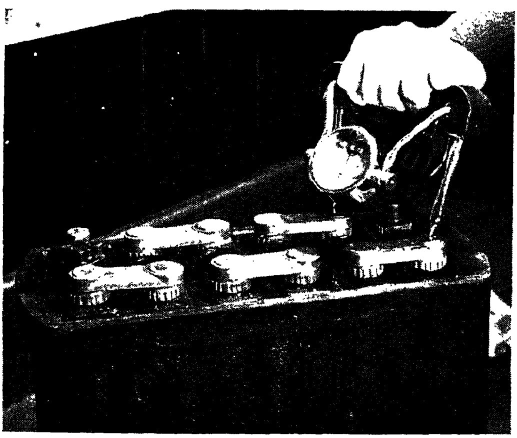


Fig. 15.—VOLTMETER TEST

Inserting Groups in Container

Fig. 8 shows how completed groups are inserted in containers. One edge is first entered and the unit kept as square with the container as possible, when it should slide easily down into position.

The operator must take particular care that the terminal posts occupy correct positions, i.e. alternate positive and negative

posts in each row, with the end terminals placed according to original layout. Groups should be pushed fully home and terminals should be all level. The lids must be fitted with care, entering squarely and pressing evenly down on the group bridges. When properly assembled, all lids should be level and flush with container edges. Fig. 9 illustrates the fitting of a cell lid.

Sealing the Battery

Sealing the battery comprises two operations: (*a*) jointing the terminals to the lids, and (*b*) sealing lids into containers.

Sealing Nuts or Rings

Batteries may be fitted with sealing nuts or rings, or the lids may have moulded collars or bushes through which the terminal posts protrude and are welded thereto. Fig. 9A is a sketch showing a sealing-ring assembly in section, and it will be noticed that the boss of the lid is clamped down against a soft rubber washer or gasket fitted on the post before lid is assembled. A thin lead washer is generally used under the ring to complete the seal outside the cell. As a " quick " square thread is used, the ring must be securely tightened, using a special pegged or slotted wrench, and locked with a punch to the post to make certain it cannot slacken. It is advisable to fit new rubber gaskets if the old ones are showing signs of perishing.

The welded seal—shown in section in Fig. 9B—has no rubber gasket, as the collar is permanently moulded into the lid. The group posts are of smaller diameter, and pass through the bore. The method of welding the lead collar and post will be described later in connection with lead-burning the links.

Heating and pouring the Sealing Compound

The second form of sealing can now be proceeded with. The compound, resembling pitch, but actually a bitumen, acid-resisting, substance with a degree of resilience when cool, is melted in a suitable container, care being necessary to avoid too rapid, or excessive, heating. The compound should be of the consistency of cream, evenly molten, with no lumps, before attempting to seal. The container must have a spout or lip capable of directing a fine steady flow, with ease of controlling the quantity of fluid, while the spout should not be too long, or it may cause premature cooling en route from container body. The can shown in sealing the battery in Fig. 10 is a good example. Another excellent method is to use an old enamelled coffee-pot. With a circular gas-ring, heat is applied to the base of the spout, keeping it at uniform temperature, while control of the stream of fluid facilitates neat, efficient work. The lids and container top—especially the trenches to receive the compound—may be slightly preheated with the lead-burner jet, keeping the flame on the move

to avoid scorching any one spot. Fluid should be poured steadily and evenly into each cell trench to a level just below cell-lid top. If hot enough, the compound should adhere readily to the trench edge and form a perfect seal. A stroke of the jet flame along each edge will raise compound temperature just sufficiently to ensure a perfect joint.

Overheating must be avoided most carefully. The compound should give off only the faintest smoke ; if temperatures rise too high, the constituent oils may be evaporated and the resultant seal loses elasticity and be liable to crack. If too cool, the compound is heavy to pour, lies thickly and unevenly in the trenches, and does not unite properly with container and lid surfaces.

If compound is run at the right temperature, there should be no need for more than the merest flick of the jet to complete edge seals, and the risk of charring moulding surfaces, which is liable to occur when jet-sealing of too-cool compound is resorted to, can be avoided.

The efficiency of the repair depends in considerable measure on correct and thorough sealing at the proper temperature.

Welding the Links and Terminals Together

The final, and nearly most important, process of lead-burning the links and terminals is a misnomer from the plumbing profession. Actually the operation consists of welding the parts uniformly to make perfect electrical contact capable of carrying currents momentarily reaching two or three hundred amps. without readable volt-drop, so its importance is obvious.

First, the collars of ringless batteries must be welded to the terminal posts to form shallow studs or posts to receive the links. A tapered-bore jig is fitted over the collar, and the oxy-gas jet adjusted to give a flame about $\frac{1}{4}$ in. across, 2 in. long, and with a blue (oxygen) tongue about $\frac{3}{4}$ in. in length. The hottest part of the flame is about $\frac{1}{2}$ in. from the end of the blue tongue, and this should be applied for a few seconds to the jig to ensure uniform heating and evaporation of condensed moisture, which is fatal to good lead-welding. The flame must be kept moving in a circle, melting and combining post and collar top, a steel spike—such as a pointed cycle-wheel spoke—being useful to assist amalgamation. More lead is added from the stick and the terminal built up to the top of the jig.

Make sure that the jig is narrow-end uppermost and that the flame is not played too long on the molten lead at the bottom, as it may run out and spoil the lid and sealing. Figs. 10A and 10B show in sketch form the shape of the finished stud and the assembly of the link ready for welding, respectively. Avoid removing the jig till cool and set. The taper bore enables it to be removed without force.

In ring-sealed batteries the new group terminals are ready formed, and links should be filed and scratched bright and then tapped into position.

Special ring jigs are used for enclosing and supporting the link while being welded, as Fig. 11 shows.

The flame should be used to preheat the jig for a few seconds, and then applied to post and link, being kept moving in a circle round the joint as amalgamation occurs and lead is added to complete the weld, as illustrated in Fig. 12. This photograph shows how the hot part of the flame is utilised, the burner having a thumb valve to control oxygen supply. It should be note that the link ends are not always the same size, and two ring jigs may be required. These are used in pairs, as shown, enabling each link to be welded on in one operation. Once the metal has amalgamated, heat should be kept away from the edge and the lead must be kept molten on top only. Otherwise it may run through under the jig and spoil the link.

Protection of Operator from Lead Fumes

The inhalation of fumes from the lead must be guarded against. In the general view of battery-shop equipment shown in Fig. 13, it will be seen that the cowl is provided at the welding bench at the far end of the shop. This is connected by a flue to an extractor fan, the front of the cowl having a glass window so that the operator has a clear view of his work, while all fumes are drawn away by air current. It will also be seen that the shop layout follows mass-production lines, batteries being passed from each operation to the next in order.

This method of layout saves time and space and enables three or four operators to work in series, handling a succession of repairs without hindrance or delay.

Other points to be considered in shop design are the maintenance of general cleanliness and order, and the safe disposal of dangerous waste material. Old plate groups must be stored in closed receptacles. Lead dust is poisonous and must be carefully avoided, and drillings and chips should be stored separately. Used sealing compound is not recoverable, but scrap metallic lead can be melted down and cast into sticks in a special mould for use in welding. The trapping of sediment has been referred to. Acid in waste water from the washing equipment should be diluted as far as possible, and it is advisable to drain and clean out the sediment tank at frequent intervals, without waiting for sediment to accumulate to any extent, when its acid content may attack unprotected metal. In this connection, the pipe supplying high-pressure jet should be heavily coated with several layers of antacid paint, and the inside of the tank lead-lined.

Making the Hydrometer Test

Methods of battery testing are illustrated in Figs. 14 and 15. The hydrometer syringe, shown in Fig. 14, is used to extract a sample of electrolyte from each cell, the depth to which the hydrometer sinks indicating density or specific gravity, which is the proportion of acid in

the solution. The process of changing drives acid out of the elements into the solution and discharging causes a degree of reabsorption, so that specific gravity is a fair indication of the state of charge. When taking readings, care is necessary to see that sufficient liquid is withdrawn to fully float the hydrometer, which must not lie against the side of the syringe. It should be held upright, as shown. Healthy cells will give a uniform reading: any one below the others indicates a fault. Acid spillage will upset proportion and should be made up with solution of the same density as that remaining. Otherwise, acid should never be added in normal circumstances, as it does not evaporate, and only distilled water is needed to restore the level.

Applying the Voltmeter Test

The loaded voltmeter test, shown in Fig. 15, should not be applied to cells with a markedly lower density than their fellows, because the load imposed may hopelessly damage an already weak cell. Age and general use must be considered in ascertaining cell condition. A battery over two years old is about due for replating.

External Indications of Plate Condition

Inspection of lids will sometimes indicate plate condition. If lids are no longer level, but tend to lift under each positive terminal, the positive groups have distorted and buckled.

Incorrect sealing of the positive-terminal post will result in the solution rising by capillary attraction and causing corroding of the cable lug.

Overtopping

Overtopping of cells may cause airlocks in the filling tubes and the solution being forced out by gas pressure. The level should not be more than $\frac{1}{4}$ in. over the separator tops and clear of the bottom edge of the filling tube. Fit new stopper gaskets where necessary, and see that the stopper gas passages are unobstructed.

Cleaning Cell Tops of Solution

If the solution has been blown out over the cell tops, the best cleaning method is a jet of hot water from a geyser. Or a kettleful poured over the battery. When evaporated, a clean, non-conducting surface results.

C.A.V. STARTERS, DYNAMOS, REGULATORS, AND CUT-OUTS

THE very extensive range of equipment manufactured by C.A.V. makes it impossible within reasonable space to give details of every item. In the following, therefore, instructions for care and maintenance are given for standard equipment, which will be found in most common use.

Before removing any equipment from a vehicle for servicing, or carrying out work on wiring or equipment while it is in position on the vehicle, it is advisable first to disconnect one of the main-battery connections in order to prevent short-circuits. If, however, a main-battery cut-off switch is fitted, this precaution is unnecessary, as operation of the switch serves the same purpose by breaking the main connection from the battery.

ELECTRIC ENGINE STARTERS

Two distinct types of C.A.V. starters are available for starting vehicle engines. Both types employ the familiar method of turning the engine by engaging a small-toothed pinion with corresponding teeth on the flywheel rim.

Non-axial Starter

For the majority of petrol engines the "non-axial" or inertia-pinion type of starter is used. This is a simple series-wound motor with an extended shaft, on which is fitted a quick-start threaded sleeve along which a freely mounted pinion travels into engagement with the flywheel. The momentum of the pinion is caused

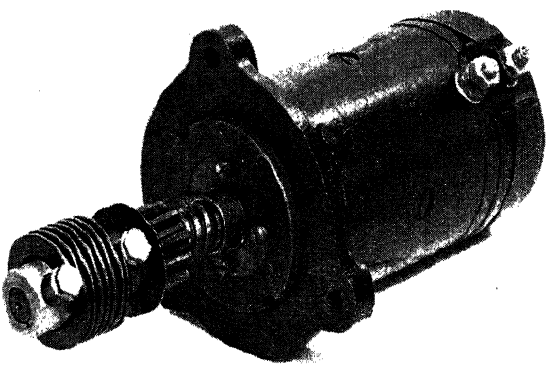


Fig. 1.—TYPICAL C.A.V. NON-AXIAL STARTER

by the rotation of the starter armature, and the actual shock of pinion engagement with the flywheel is usually absorbed through a large-section coil spring.

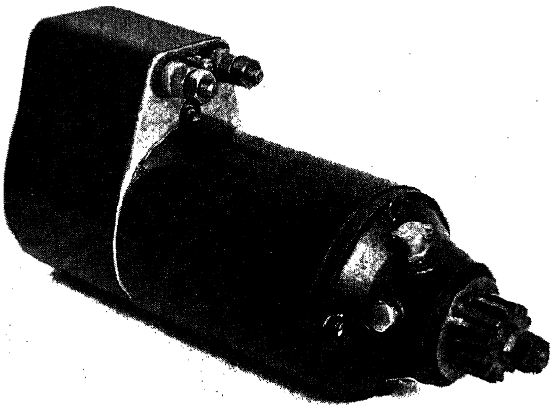


Fig. 2.—C.A.V. AXIAL-TYPE STARTER.
Showing the pinion in the disengaged position.

Axial Starter

The production of a completely successful electrical starter for engines of large horse-power introduced many difficulties, which were not completely overcome until the introduction of the axial type of starter. As its name implies, the "axial"-type starter is so termed because its armature and pinion slide with an axial movement in the bearings at the same time as they rotate, so that in the extended position the pinion engages with the teeth on the flywheel rim. The pinion is held in the disengaged position by means of a coil spring fitted inside the shaft at the commutator end. The operation of the axial starter is positive, and the risk of damage due to engine backrock or faulty meshing of the pinion with the flywheel teeth is reduced to a minimum.

Operation of Axial Starter

The field windings of the axial starter are divided into the main series, auxiliary series, and shunt coils.

When the starter push is operated, a current passes through the shunt- and auxiliary-series windings, which causes the armature to rotate slowly. At the same time the magnetic field in the poles acts upon the armature which, when disengaged, is out of complete register with the poles. The solenoid effect upon the armature pulls it forward, so that the pinion meshes gently with the engine-flywheel teeth, and at the same time a disc on the armature shaft trips a small lever which releases a catch and allows the main contacts in the solenoid switch to close. Thus it will be seen that it is only when the pinion is nearly in complete mesh with the flywheel that the main current can flow through the solenoid switch and energise the main starter series winding so that the full starting torque is applied. This feature ensures a positive and quiet engagement,

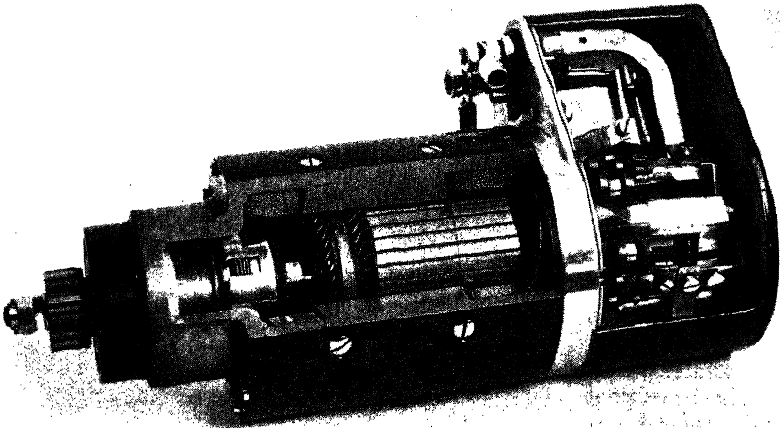


Fig. 3.—C.A.V. AXIAL-TYPE STARTER (BS6) SECTIONED TO SHOW INTERNAL CONSTRUCTION

without any violent engaging impact and consequent damage to pinion and flywheel teeth.

Directly the engine fires and gets under way the main current is greatly reduced, together with the strength of the magnetic field, so that the spring tension overcomes the force exerted by the magnetic field, and the pinion automatically disengages. This is not so, however, on machines fitted with "holding-on" windings, in which the pinion is held in mesh with the flywheel teeth until the starter button is released. A further outstanding feature on the axial starter is the provision of a multi-plate friction overload device which prevents damage occurring due to engine backrock, and is a positive safeguard against the pinion teeth being sheared due to excessive load. It is a simple device employing a screw and spring-loaded clutch assembly, which is so arranged as to have a slipping torque of approximately 1½ to 3 times the starter lock torque.

When using Starter

Points to remember when using starter :

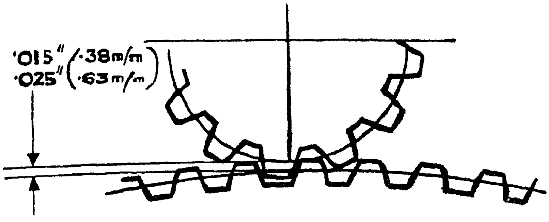
Make sure all engine controls are correctly adjusted.

Release the switch as soon as the engine fires.

If the engine does not fire at once allow it to come to rest before pressing the starter switch again.

Do not use it continuously if the engine will not start. Ascertain the cause of failure.

With some engines it is often helpful to depress the clutch when starting.



4.—CLEARANCE BETWEEN FLYWHEEL TEETH AND STARTER PINION

On no account should it be operated while the engine is running, otherwise serious damage is likely to occur to both starter and flywheel teeth.

Starter Maintenance

Although there is a distinction between axial and non-axial types, the majority of items of maintenance apply equally to both types, and it is, therefore, possible to consider the following as applicable to both axial and non-axial types except where a distinction is indicated.

Mounting

When a starter is mounted by the manufacturer, care is taken to ensure that clearances between the starter pinion and flywheel teeth

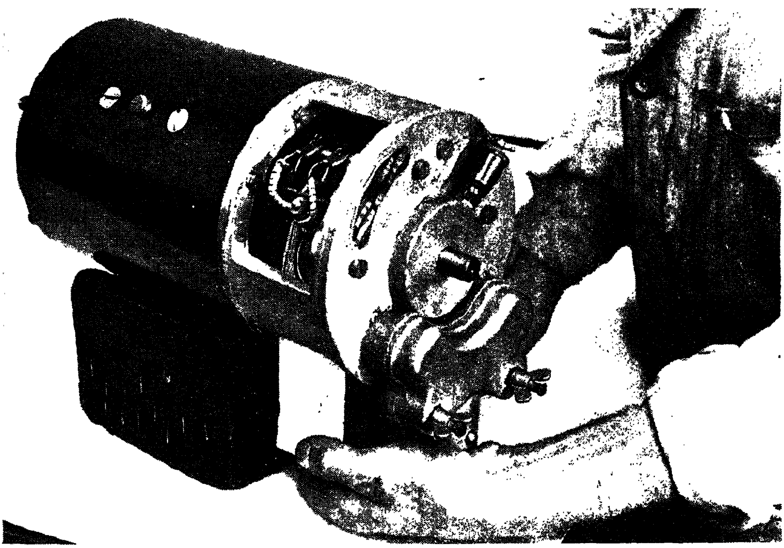


Fig. 5.—METHOD OF BEDDING IN CARBON BRUSHES

Wrap a strip of very fine glass- or carborundum paper firmly round commutator and with brushes in position rotate armature by hand in normal direction until correct brush shape is obtained.

are maintained. Insufficient care, however, is often shown when the starter is remounted during service, and incorrect clearance is often the unsuspected cause of trouble.

The pitch-line clearance between pinion and flywheel should be ·015–·025 in., and the distance between centres may be calculated simply thus:

For example, Flywheel with 145 teeth,
pinion with 13 teeth,

$$\text{centres } \frac{145 + 13}{2 \times 8} + \cdot015 \text{ min.} = 9\cdot890 \text{ in.}$$

$$\frac{145 + 13}{2 \times 8} + \cdot025 \text{ max.} = 9\cdot900 \text{ in.}$$

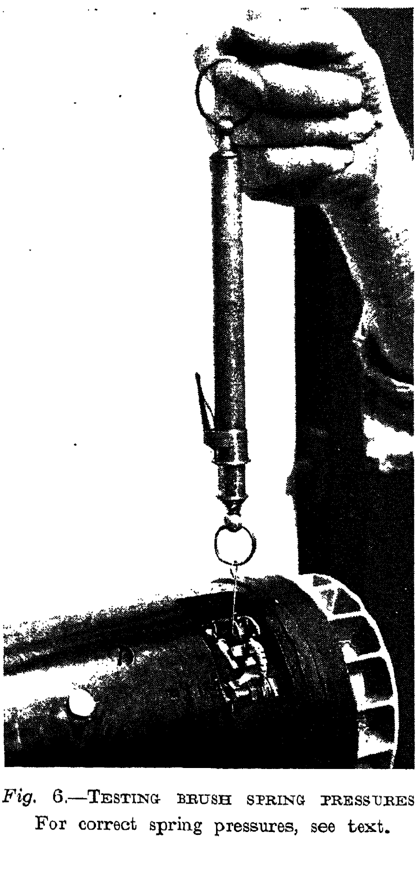


Fig. 6.—TESTING BRUSH SPRING PRESSURES
For correct spring pressures, see text.

Another important but often neglected dimension, which has considerable bearing on the pinion engaging speed and consequent life of the pinion, is the distance between the engaging faces of the flywheel and pinion when the starter is at rest; this should be:

Axial: $\frac{1}{8}$–$\frac{5}{32}$ in. full travel of armature $\frac{31}{32}$ in.

Non-axial: according to size and type of machine.

Brush Gear

Inspect the brushes at regular intervals of, say, every 5,000 miles. If they are withdrawn completely from their boxes, take care to replace them in exactly the same position in their boxes. This will ensure that the bedding curvature of the brush face will conform accurately with the commutator periphery.

Replacement of Brushes

If for any reason it is not possible to replace brushes in their former positions, or if new brushes are fitted, they should

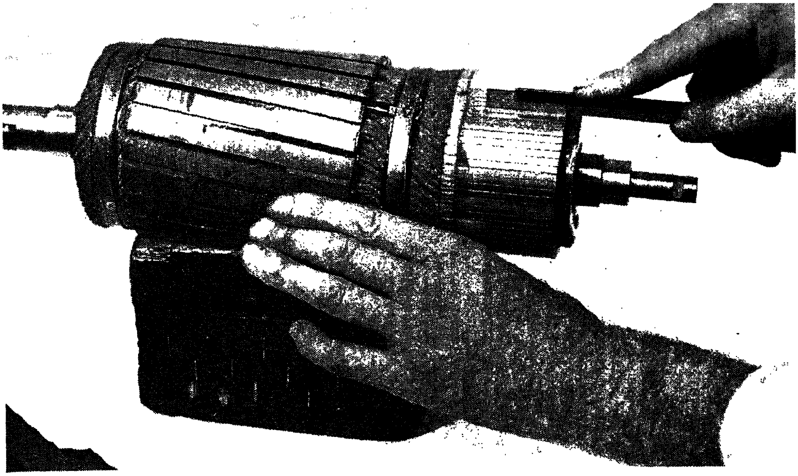
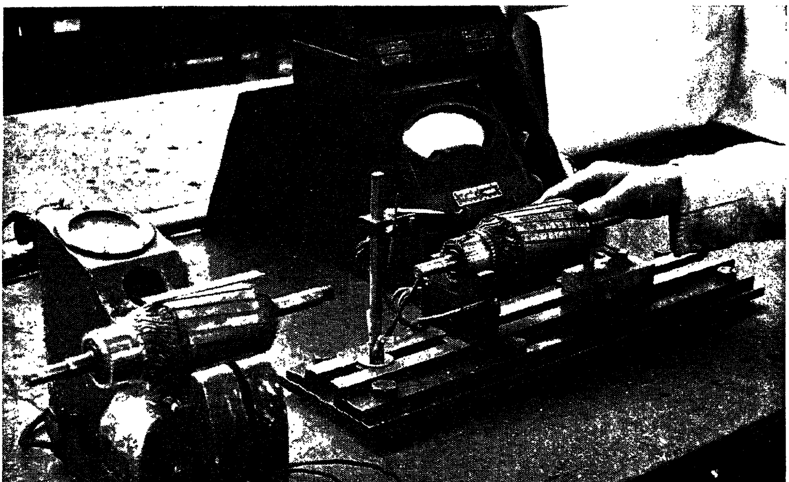


Fig. 7.—UNDERCUTTING COMMUTATOR MICA

The mica insulation between the commutator segments should be removed to a depth of $\frac{1}{32}$ in. below the copper surface.



8.—ARRANGEMENT OF ARMATURE TESTING APPARATUS

The continuity of the armature coils is being tested in a simple jig on the right. This method of testing is described in the text. A growler is shown on the left.

be "bedded" before the machine is run. This simple operation can be carried out by wrapping a strip of very fine glass- or carborundum paper (do not use emery cloth) firmly round the commutator, and with the brushes in position rotate the armature by hand in the normal direction of rotation until the correct brush shape is obtained.

Brushes should be free in their guides. Badly worn brushes will cause trouble because the brush trigger or spring can no longer provide effective pressure.

It is essential that replacement brushes are of the same grade as those fitted originally to the machine, also that the brush-spring pressures are not altered. Test the brush-spring pressures (*see* table) by means of a spring-balance hooked under the spring trigger or spring tips. The pressure can be varied on the majority of C.A.V. machines by twisting the spring into different slot locations on the trigger.

Brush-spring Pressures

SC, S5, ZBB, ZAB12VOLT	24–32 ounces
ZAB24VOLT	36–48 ,,
BS512 and BS524VOLT	32–40 ,,
BS612 and BS624VOLT	18–24 ,,

Attention to Commutator

Good commutation is essential for the consistent and trouble-free running of any starter. The commutator surface should be clean and free from uneven discoloration.

Any deposit bridging the segments across the intersegment insulation should be removed, and the commutator surface cleaned with a very fine grade of glass- or carborundum paper (do not use emery cloth).

Skimming Commutator in Lathe

If it is found impossible to clean the commutator by this method, or if the surface is badly pitted, it will be necessary to skim the commutator in a lathe. Only a very light cut should be made, and a diamond-tipped or wimet-tipped tool used to ensure a high-quality finish.

Undercutting Commutator

The commutator should be "undercut" after turning, i.e. the mica insulation between the commutator segments should be removed to a depth of $\frac{1}{32}$ in. below the copper surface, care being taken to remove the full width of mica and to leave nothing to project above the copper. For this operation may be purchased a special tool, which generally takes the form of a small saw-blade, complete with handle and a heavy reinforced back to the blade in order to assist steadiness in use. An old hack-saw blade will, however, make a serviceable tool in an emergency.

Testing the Armature Coils

When a commutator has been examined and reconditioned according to the above, and intermittent running of the machine is evident, the

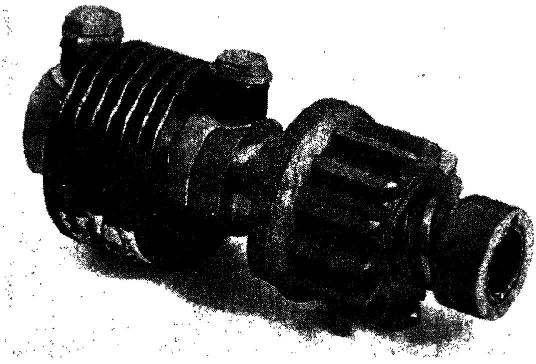


Fig. 9.—NON-AXIAL-TYPE STARTER DRIVE

possibility exists of one or more of the armature coils being either burnt out or damaged. Continuity of armature coils via the armature can be tested on a simple jig, which is shown in Fig. 8. The armature is mounted between centres on a fixture on which are also fixed two carbon or copper brushes, mounted at an angle of 90° to each other and in such a position that they can be made to contact with the commutator periphery. A car battery is connected to the two brushes, and a milli-volt meter is required complete with two hand-spikes. A variable resistance should be included in the battery circuit, capable of carrying the full output of the battery and adjusted to give 2 volts or less on the armature. To carry out the test the hand-spikes are applied to two adjacent commutator bars and the milli-volt meter reading recorded. This procedure is continued all the way around the commutator surface (each bar being used twice in succession) until all bars have been tested and the readings recorded.

If all the coils are in order the readings should be approximately the same, any big variation, therefore, indicating a fault in the coil connected to the respective commutator bar. It is useful to know that, generally speaking, a reduction in milli-volt reading indicates a short-circuit, whilst the converse shows either a faulty connection or an open circuit.

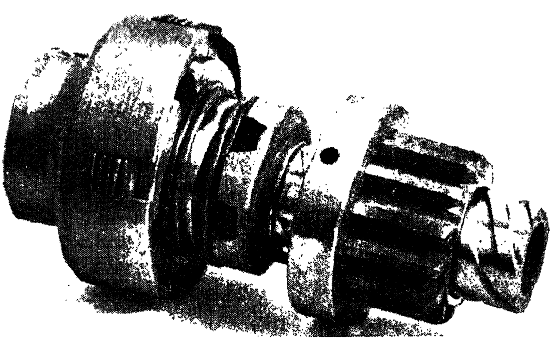


Fig. 10.—C.A.V. TYPE IC STARTER DRIVE

Field Coils

Unless particulars of windings, resistances, etc., are known for each

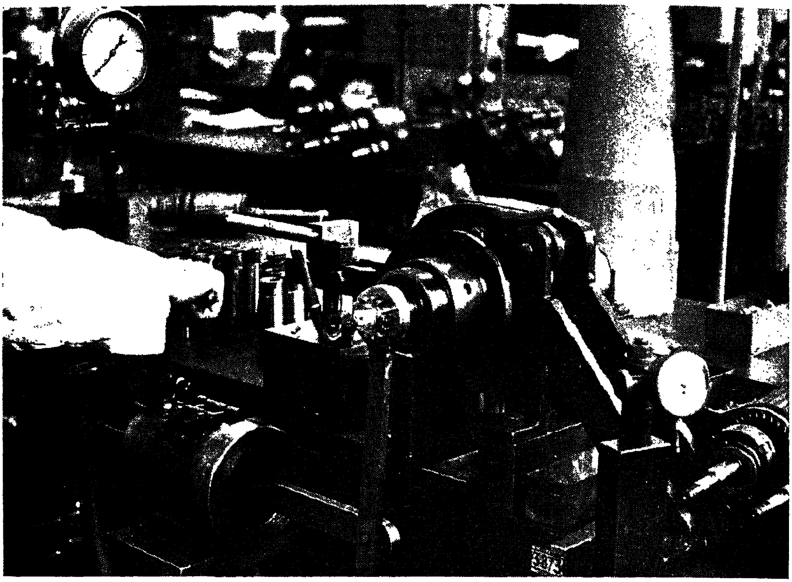


Fig. 11.—APPARATUS FOR TESTING CLUTCH TORQUE ON AXIAL-TYPE STARTERS

particular type, a successful test cannot be undertaken. It is possible, of course, on machines with straightforward windings to test for continuity and internal shorts, the latter test being carried out by comparing the resistance registered in each coil by means of an ohmeter. Alternatively, the voltmeter-ammeter method may be used. As the resistances of the coils should be within 6 per cent. of each other, any excessive variation registered in any single coil shows that coil to be faulty.

Lubrication

The majority of non-axial starters are fitted with oil-less types of bearings which do *not* need lubricating. There is, in fact, a danger of the self-lubricating properties becoming affected if lubrication is attempted.

When lubricators are fitted to non-axial types a soft grease, as used for general chassis lubrication, is recommended.

Axial-type starters are fitted with greasers at the commutator end. These should be kept filled with the recommended grease, grade Bol.1.iv.10, but should not be over-lubricated. Over-lubrication is liable to cause costly damage through burned commutators, and saturated armatures, field coils, switch, etc.

STARTER DRIVE

Non-axial Starter

The pinion of non-axial starters should be kept free in travel. The screwed sleeve should be cleaned with paraffin and lubricated with thin machine oil.

Some drives are fitted with a light spring to prevent the pinion from creeping into engagement with the flywheel through vibration. This spring should be kept perfectly free and its efficiency maintained.

A small retarding plunger fitted to pinions with counter-weights must be kept free in operation.

Axial Starters

The pinion on axial starters requires little attention. It is kept lubricated automatically by a felt wick in the driving-end shield; that is, of course, provided the lubricators are kept well filled, but not overfilled.

Bearings

When wear occurs in bearings they should be replaced and no attempt made at reboring. Replacement of bearings calls for very accurate workmanship, and unless adequate facilities exist for extracting and replacement it is advisable to have the work carried out by the manufacturers.

Clutch

As previously mentioned, all axial-type starters are fitted with an overload device to prevent damage occurring due to engine backfire. On certain 5-in. diameter non-axial starters fitted with the type IC drive, a clutch arrangement, similar to that used on the axial machine, is also fitted.

Before any attempt is made to replace plates or any other parts in a clutch it is necessary to have test gear available, similar to that shown in Fig. 11.

When new plates are fitted, care should be taken to insert them alternately bronze and steel. A bronze plate should be inserted first into the housing, followed by a steel one, and so on alternately, in order that the last one will be steel to take the pressure of the small springs.

After the clutch has been assembled it must be adjusted to slip at 100–115 lb. ft. torque, and tested about ten times. After this test the clutch should be adjusted to slip at 80–100 lb. ft., and if it slips with less than 80 lb. ft. torque, compensating washers must be inserted between the plates and the back ring until the correct slip is recorded. These

washers are available in two thicknesses, ·1 and ·15 mm. respectively.

Terminals

Fixing nuts and screws on terminals should be kept tight and clean. Where rubber caps are supplied for covering the terminals they should be used, because they provide protection against accidental short-circuits.

Care should be taken when disconnecting cables to replace them on the same terminals.

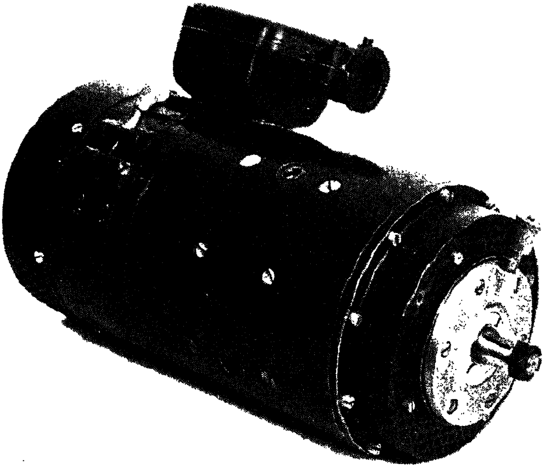


Fig. 12.—Typical 8-in. diameter C.A.V. compensated voltage control dynamo

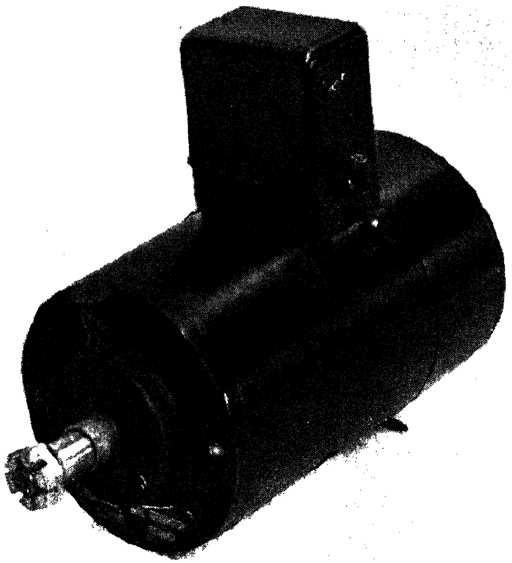


Fig. 13.—Typical C.A.V. dynamo with combined regulator and cut-out, mounted on yoke

Starter Switches

The design of the axial starter incorporates a solenoid - operated switch. This switch plays an important part in the operation of the machine, and will be found dealt with in detail under the heading of "Switches and Switchgear." Details of starter switches used in conjunction with non-axial starters will also be found described in the same section.

"Don'ts" to Remember Regarding Starters

Don't—

Attempt to rebore the poles or re-machine armature cores of axial starters, because this will upset the engaging action of the starter.

Use other than proper brushes. Incorrect grades will result in bad commutator surface and pitting through excessive sparking; possibly, also, in loss of power.

Use other than recommended lubricants. Incorrect lubricants cause excessive bearing wear.

Damage armature core when holding it for torque test of clutch. Short-circuits in windings may occur or the air gap between poles and armature may be affected.

Bend or damage axial-starter tripping plate on armature, otherwise the timing or pinion engagement will be altered.

Let oil or dirt come into contact with the commutator. This may cause short-circuits between commutator bars, uneven brush wear, a bad commutator surface, and breakdown of insulation.

Be over-enthusiastic with lubricant. Oiling is very necessary on some machines, but if excessive will result in saturated windings and cause premature breakdown of insulation.

DYNAMOS

The majority of C.A.V. dynamos are now designed for the compensated-voltage control system. This system makes the provision of a dynamo charge-control switch unnecessary, as the charging current is controlled automatically by the voltage regulator, in order that the battery may be fully charged and yet be protected from the possibility of its becoming overcharged. Once the dynamo speed has exceeded cutting-in speed, its output voltage is kept slightly in excess of the back pressure of the battery, irrespective of any variation in speed. In addition, the excess voltage is increased as the battery becomes discharged and reduced correspondingly as the battery becomes more highly charged.

It is the usual practice to mount in a separate control board the regulator and cut-out for use in conjunction with compensated voltage-control dynamos. On small-type machines, however, either a regulator or combined regulator and cut-out unit will be found mounted directly on the yoke of the machine.

Checking Performance

The performance of a dynamo can be checked if the following simple test is applied:

Connect a "centre zero" ammeter in the main connection between the lamp-load and positive-battery connection. Run the dynamo at 1,200 r.p.m. or more and switch on all lamps. A small discharge should at first be registered in the ammeter if the battery is well charged, which

will gradually become less and less ; and within an hour should commence to show a charge. If, however, the battery is discharged at the commencement, the ammeter will indicate a charge immediately and the more the battery is discharged the higher will be the charging rate.

General Maintenance

Armatures and field coils on dynamos are similar in construction to those fitted in starters, and for this reason the maintenance instructions given for starters can be considered as applying equally to dynamos.

Brush Gear

Brush-gear maintenance on dynamos is also similar to that given for starters on page 444, except that the brush-spring pressures vary according to the respective dynamo types, as follows:

Dynamo	*Pressure in Ounces*
D45R	25–27
D45B, C, and D	15–16
DBR, DBLR, DBN, DBLN	20–22
DA, DOA, DR, DOR, DRA	30–33
M, MO, MR, MOR, MVR	23–35
D7X, DO7X, D7C, D7CF, D8C	13–14
MYR, MOYR, MYS, MYRA	24–26
D65B, DO65B, D65C, DO65C	15–17
D5L, D5LF	14–16
G55F24	12–13

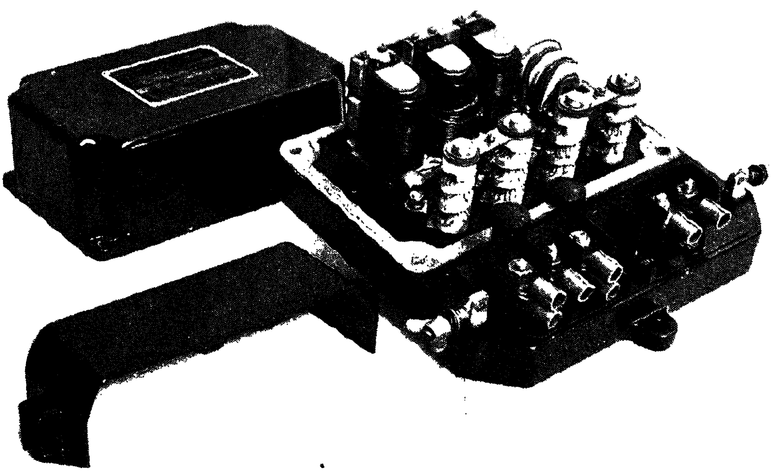


Fig. 14.—C.A.V. CONTROL BOARD, TYPE 37F, WITH COVERS REMOVED

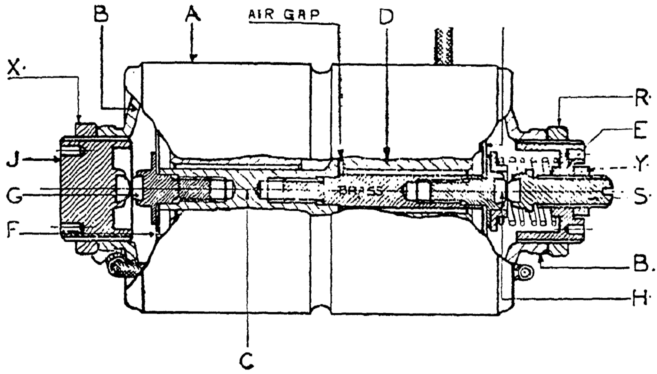


Fig. 15.—PART SECTION OF C.A.V. B2-TYPE REGULATOR

Lubrication

All dynamos are fitted with large grease-cups on each end of the machine for applying grease to the bearings. Either roller or ball bearings are fitted, which are packed with grease when the machine is first manufactured. It is, however, necessary to give the greasers a half-turn approximately every three weeks to ensure that a good supply of grease is available at the bearings. When refilling the grease-cups it is important to use only a good-quality high-melting-point grease.

Regulator and Cut-outs

The maintenance of these items is explained under their separate sections on the following pages.

General Maintenance Hints

The following points should be observed and checked when refitting a machine to an engine after overhaul or replacement :

(*a*) The driving pulley or other member should be clamped tightly between the shaft collar and shaft nut on machines fitted with parallel shafts. On machines fitted with tapered shafts, the driving member should be located firmly on the taper to ensure even and quiet running.

(*b*) Greasers should be accessible and preferably above the horizontal centre-line.

(*c*) Careful alignment of the dynamo axis with the driving coupling, or any other equipment to which the dynamo is coupled, will ensure maximum ball-race life. Flexible couplings should be used wherever possible.

(*d*) See that the band cover can be easily removed to facilitate brush replacement and inspection.

(*e*) Particular care should be taken to replace shaft keys when remounting the pulley or coupling.

(*f*) Terminals or terminal boxes should be kept well away from obstruction, to prevent short-circuits and damage to cables.

(*g*) Air inlets and outlets on fan-ventilated machines must be away from any source of heat and kept perfectly clear. They should also be shielded from access of road dirt and water.

(*h*) Considerable damage can be caused by oil and water leaking from an engine and entering a dynamo. Very great care should be taken if the dynamo is near the crankcase breather, fuel pump, etc., to see that neither the fuel oil or oil vapour enter the dynamo.

(*i*) Cradle-mounted machines should fit squarely across the cradle flanges and be accurately located by the dowel.

(*k*) Cradle straps must be tightened evenly a little at a time, and should not foul the dynamo-cover band.

(*l*) Flange fixing bolts should be tightened evenly, care being taken that the flange locates firmly in its spigot.

(*m*) Always replace the split-pin locking the driving-shaft nut on flange-mounting machines.

CONTROL BOARDS, REGULATORS, AND CUT-OUTS

Control Boards

C.A.V. control boards are used in conjunction with compensated-voltage control dynamos. They are mounted separately from the dynamo and include, under a dustproof cover, the regulator, cut-out, fuses, and various resistances.

Terminals are also fitted for cable connections, and junction points which are accessible under an easily removable cover mounted separately from the main cover.

When the control board is dispatched from the manufacturers, the regulator cover is sealed in order to prevent any unwarranted interference with regulator or cut-out. This precaution is necessary because the satisfactory working of any compensated-voltage control equipment is maintained entirely by the regulator and cut-out, and unless facilities exist, therefore, for accurate testing and setting it is advisable to return the complete unit to the manufacturer when readjustment or overhaul becomes necessary. The procedure to be adopted when adequate facilities do exist are given later.

Sizes and types of control boards vary considerably, according to the dynamo and battery with which they are required to work in conjunction. Particular attention should be paid to the details given on the instruction label permanently fixed to the cover, which states clearly the type of dynamo and battery for which the control board is suitable. These instructions should be rigidly adhered to unless the manufacturers

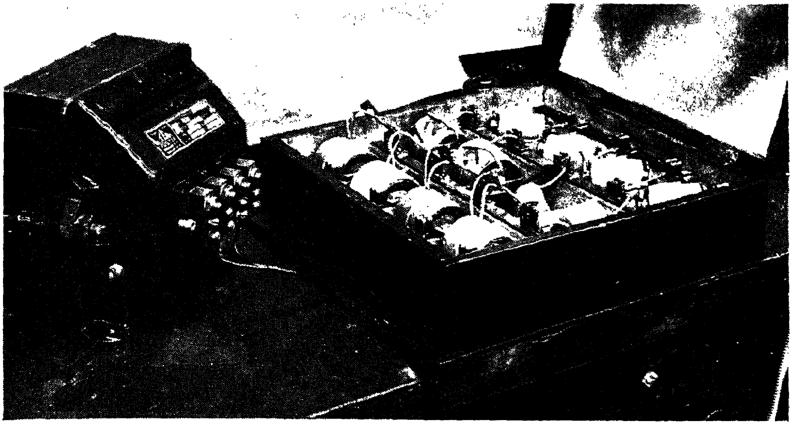


Fig. 16.—C.A.V. BARREL-TYPE REGULATOR UNDERGOING "BUZZER" TESTS

have been consulted as to the satisfactory working of the control board with any other equipment.

Fuse Values

Fuse values are important. On nearly all types of control boards spare fuses are provided which should be used for replacements. Should genuine replacements not be available, care should be taken to use a fuse of exactly the same rating as the one previously used. On C.A.V. cartridge and strip-type fuses the rating will be found stamped on the ends of the fuses.

Regulators

The correct and satisfactory working of the compensated-voltage control system is dependent upon the voltage regulator as described later. Various types of regulators are available, all of which are described in this section under their various-type headings. A careful note should be made of the type symbol marked on the regulator before any adjustment or work is carried out.

Regulators—Types B1 and B2

These are barrel-type regulators identical in design, the only difference between the two being in the winding and outside diameter, which for type B1 is $2\frac{3}{8}$ in. and for B2 $1\frac{7}{16}$ in.

Referring to Fig. 15, it will be seen that two end caps (*B*) are permanently fixed to the main body (*A*) by spinning over the ends of the body. In the centre of the regulator is the armature (*C*), into which is screwed the brass distance-piece (*D*). The armature and distance-piece are held

in a floating position by springs (*F*), through the medium of contact screws (*G*) and (*H*). Adjustable contact screws (*J*) and (*S*) are screwed into the end caps, and locked into position by locknuts (*X*) and (*Y*). Adjustment of the regulator can be controlled over a wide range of speed by adjustment of these pairs of contacts, one pair of which is arranged to insert a resistance in the field circuit of the dynamo, and the other pair to short-circuit the dynamo field when the dynamo is running at high speeds.

Testing B1 and B2 Regulators

Should trouble occur with the lighting equipment, or bad starting be evident through run-down batteries, it is advisable to test the open-circuit regulator voltage in order to ascertain if it is within the prescribed limits.

On the metal label fixed under the locknut (*R*) is marked the regulator-type formula, the last figure of which indicates the voltage setting according to the list set out below. For example, regulator marked B1E2—No. 2 setting in list, i.e. 14·0–14·5 volts.

Voltage Settings for B1 and B2 Regulators

Voltage settings covering the B1 and B2 regulators are as follows:

B1 REGULATOR

Symbol No.	*Open Circuit Voltage Setting*
1	15·0 –15·5
2	14·0 –14·5
5	14·5 –15·0
6	16·0 –16·5
8	13·75–14·25
9	14·75–15·25
10	14·5 –15·0
11	DV. { 15·0 –15·5 16·0 –16·5
13	DV. { 15·5 –16·0 17·5 –18·0
41	14·25–14·75
42	DV. { 15·0 –15·5 16·0 –16·5
21	10·0 –10·5
22	30·0 –30·5

B2 REGULATOR

Symbol No.	*Open Circuit Voltage Setting*
1	15·0 –15·5
2	14·0 –14·5
3	15·5 –16·0
5	14·5 –15·0
6	16·0 –16·5
8	{ 16·0 –16·5 15·0 –15·5 } DV.
9	14·5 –15·0
10	17·5 –18·0
14	7·5 – 8·0
21	7·25– 7·75
22	7·75– 8·25
23	7·5 – 8·0
32	5·5 – 6·0 set on 10/11 amp. load.

When the voltage setting is known, the regulator should be tested on open circuit; that is, with all load due to lamps and other accessories switched off and with the battery disconnected. A voltmeter should be connected across the dynamo terminals and the dynamo run at a speed between 1,000 and 1,500 r.p.m. If the recorded voltage does not fall within the prescribed tolerance it is necessary for adjustment to be made.

When this test is being made the regulator must be cold.

Adjusting B1 and B2 Regulators

It is important that the various operations described should be carried out in the sequence given :

(1) Slacken back locknuts (*X*), (*R*), and (*Y*).

(2) Screw back contact (*J*).

(3) Screw back second contact (*S*) as far as possible.

(4) Screw back the sleeve (*E*).

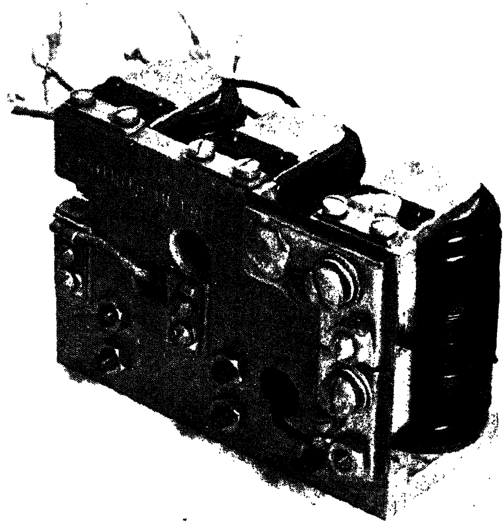


Fig. 17.—C.A.V. OPEN-TYPE REGULATOR " BJ

(5) Screw in the first contact (*J*) until the armature (*C*) makes contact with the sleeve (*D*).

(6) Screw back the first contact two complete turns on the B1 regulator and one-and-a-half complete turns on the B2 regulator.

(7) Lock the first contact screw (*J*) in this position by means of the locking nut (*X*).

(8) Connect the regulator to a suitable dynamo and run the dynamo at approximately 1,000 r.p.m.

(9) Screw in sleeve (*E*) until the required voltage setting is obtained.

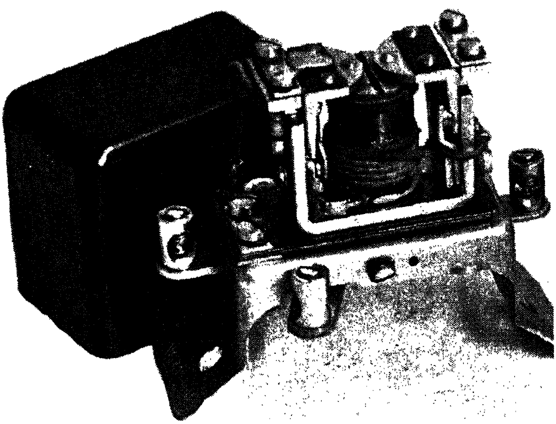
(10) Lock sleeve (*E*) in position by means of locknut (*R*).

(11) Stop the dynamo. Screw in the contact (*S*) as far as it will go. Turn contact (*S*) back one complete turn.

(12) Check the voltage-setting readings. If after a speed of 1,000 r.p.m. is reached the voltage rises, stop the dynamo. Screw the contact (*J*) in slightly and readjust (*S*) as in (11). If the voltage drops, unscrew contact (*J*) slightly and readjust (*S*).

It should be particularly noted that the adjustment of contact (*S*) is possible only while the dynamo is stationary. If the contact is screwed up while the dynamo is running a short-circuit is caused on the dynamo, resulting in a fusing or welding of the regulator points.

Regulators used in conjunction with ten-cell Nife batteries are supplied with an extra " low-voltage " lead, and for this type two voltage-setting figures are shown on the label. The second figure should occur



18.—C.A.V.-TYPE "BG" REGULATOR FOR DYNAMO MOUNTING—COVER REMOVED

when the double-voltage lead is connected to dynamo positive, all connections to the low-voltage dynamo terminal being disconnected.

Maintenance of B1 and B2 Regulators

With the exception of contacts, very little should need attention during the life of the regulator. After prolonged periods of running the contact should be inspected and, if dirty, cleaned with spirit or very fine carborundum paper ; a file or coarse grit should not be used in any circumstances. If they are badly burnt or pitted they should be replaced by genuine C.A.V. spare parts, and the following procedure adopted for their removal :

(1) Contact (*J*). Release locknut (*X*) and unscrew contact.

(2) Contact (*S*). Release locknut (*R*) and unscrew sleeve (*E*). The contact (*S*) can be screwed out of the sleeve after releasing the locknut (*Y*).

(3) Moving contact (*G*). Hold contact (*H*) by means of a box-spanner, or preferably a bench fixture. By means of another box-spanner, remove contact (*G*) and immediately insert the new contact.

Extreme care must be taken with the operation of unscrewing the old contacts and screwing in the new ones, as, if excessive pressure is applied, the support springs (*F*) will be distorted and the operation of the regulator interfered with.

(4) Moving contact (*H*). Proceed in exactly the same manner as contact (*G*).

It is necessary when new parts are fitted that they should be "bedded" down before placing the regulator into service. The apparatus required for this operation is simple and the small outlay required will be amply repaid by the resultant consistent running of the regulator during service.

An alternating-current mains supply is required to be stepped down by means of a transformer to an output of 20 volts, which is suitable for testing 6-, 12-, or 24-volt regulators. Connection is made from the 20-volt supply to the shunt winding of the regulator through the medium

of the connections fitted under locknuts (*X*) and (*R*). When the current is switched on, a violent oscillation is produced in the regulator contacts, corresponding with the frequency of the alternating-current supply. The current should be left on for approximately half an hour, at the end of which time the regulator can be placed in service, provided that the voltage settings have not changed. They must be checked after regulator has cooled down thoroughly.

It should be noted that the open-circuit regulator settings will be a little high if tested directly after the buzzing test owing to the regulator being hot.

Combined Regulators and Cut-outs—Types BJ and BK

Types BJ and BK are of the single-unit construction, incorporating both regulator and cut-out, each having its own core and windings.

Type BJ is for use with large dynamos fitted with two sets of field coils. It is fitted with three bobbins and armatures, of which two are for the regulators and one is for the cut-out.

Type BK is similar to type BJ, but is used with smaller-type dynamos. It is fitted with only two bobbins and armatures, one each for the regulator and for the cut-out.

Testing Combined Regulators and Cut-outs

On every regulator will be found stamped the type number in a conspicuous position. For example, BJ4–285, which indicates the voltage setting as well as the type. The last figure in the group symbol is decimal, with which a tolerance of plus $\frac{1}{2}$ volt is allowed. It will be seen that the voltage setting can be quickly derived, that in the example being 28·5–29·0 volts. The cut-out voltage is as a rule set between 1–1·5 volts below the minimum regulator setting.

When the voltage setting has been derived from the type formula, the regulator is tested on open circuit after the battery and load have been disconnected in the same manner as described for the B1 and B2 regulators. If, when tested, the setting does not fall within the $\frac{1}{2}$-volt tolerance allowed, adjustments should be made according to the following instructions (the letters referred to are those shown in Fig. 19):

(1) Slacken off screws (*A*) attaching the flat springs to the frame.

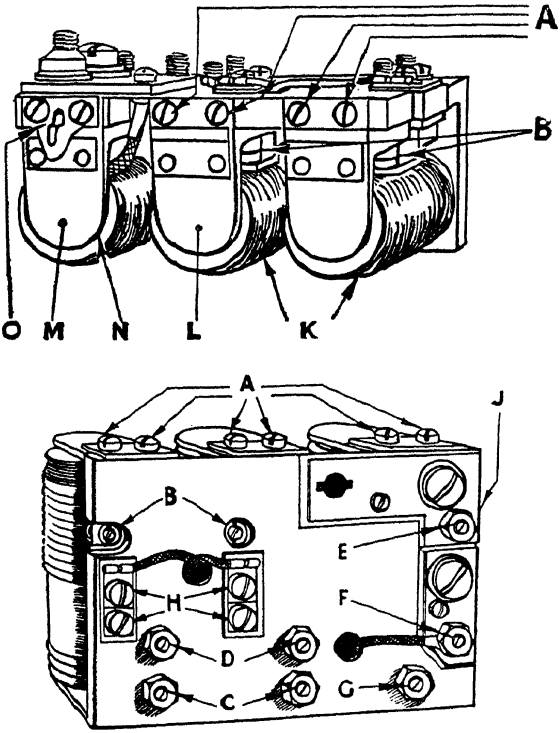
(2) Slacken off adjustable contacts (*B*).

(3) Slacken off pressure-spring adjusting screws (*C*) and (*D*).

(4) Press armature down on to core and back against frame. It is essential that there is no air gap between core or frame.

(5) Tighten screws (*A*).

(6) Adjust contacts (*B*) so that the gaps between core and armature lies between 1·2 and 1·4 mm., measured at the armature tip.



KEY TO FIG. 19.

A. Armature fixing screws.
B. Adjustable regulator contacts.
C. Regulator voltage setting screws.
D. Regulator voltage setting auxiliary screws.
E. Adjustable main cut-out contacts.
F. Adjustable auxiliary cut-out contacts.
G. Cut-out voltage setting screws.
H. Screws holding regulator fixed contacts.
J. Main regulator frame.
K. Regulator coil.
L. Regulator armature.
M. Cut-out armature.
N. Bobbin core.
O. Cut-out armature regulating stop.

Fig. 19.—" BJ " REGULATOR AND CUT-OUT

KEY TO FIG. 21.

A. Main frame.
B. Core.
C. Bobbin.
D. Armature.
E. Moving contact strip.
F. Spring support.
G. Armature spring.
H. Locking piece.
J. Adjusting nut.
K. Terminal block.
L. Terminal screw.
M Fixed contact strip.
N. Packing shims.
P. Fixing screws for contact strip.
Q. Terminal screw.

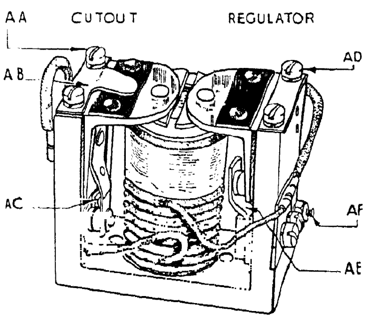


Fig. 20.—" BG " REGULATOR AND CUT-OUT

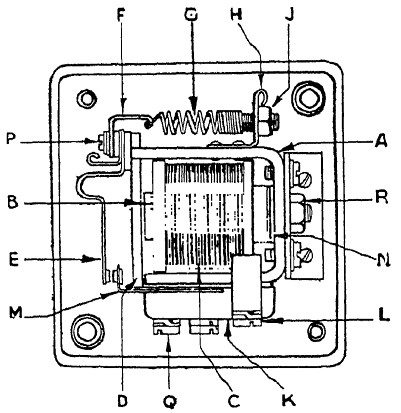
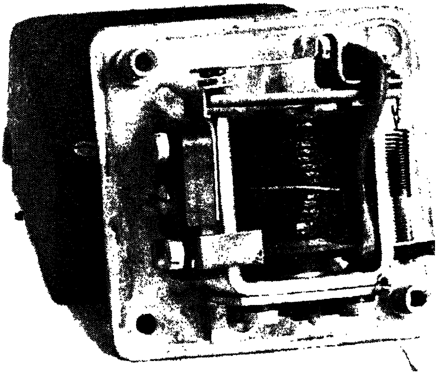


Fig. 21.—" DR "-TYPE CUT-OUT

Electrical Setting



22.—TYPICAL C.A.V. CUT-OUT, TYPE

(7) The required open-voltage setting is obtained by the adjustment of screw (*C*). To raise the voltage, screw downwards; to lower, unscrew upwards. The stop-screw (*D*) should then be adjusted until it touches the bronze armature spring and then screwed back one-and-a-half turns to leave a gap. The dynamo should be stopped and restarted several times, in order to make sure of the correct adjustment. It should be particularly noted that in the case of the BJ regulator the two bobbins should be adjusted separately by disconnecting each dynamo field in turn and then finally balancing them as near as possible together with both dynamo fields connected.

Cut-out Settings

Settings are effected in a similar manner to the regulator setting, and it is permissible to remove the armature, if necessary, for contact cleaning. When the armature is replaced, or needs adjusting, the following operation should be carried out in sequence (*see* Fig. 19):

(1) Slacken off screws (*A*) attaching flat spring to frame.

(2) Slacken off, to separate, main contacts (*E*) and auxiliary contacts (*F*).

(3) Insert feeler gauges 0·1 mm. thick between armature and frame.

(4) Press armature down on to the core and back against feeler so that feeler is gripped firmly.

(5) Tighten clamping screws (*A*).

(6) Screw down main contact (*E*) until gap between the armature tip and core is 0·5 mm., when contacts are closed.

(7) Set armature gap with contacts open to 1·4 mm. by bending the armature stop (*O*) gently or tapping lightly with a screwdriver.

(8) Adjust auxiliary contacts (*F*) to close when main contacts are still 0·2 mm. open.

Adjust screw (*G*) so that armature operates at 1–1·5 volts below minimum open-circuit regulator voltage.

In the unlikely event of the contacts being found to be in a dirty condition, they should be cleaned with very fine carborundum paper and a chamois leather dipped in 95 per cent. pure ethyl alcohol.

Regulator Type BG

A small combined regulator and cut-out known as type BG is used for the C.A.V. 4½-in. dynamo type D45D. This regulator is screwed direct to the dynamo yoke, and is not fitted in an external control board as customary with the larger dynamos.

Take care to avoid confusion with the old type F regulator fitted to dynamo types D45B and C, because externally both the F and BG bear a close resemblance. Internal construction, however, is very different, and it is *not* possible to use the BG-type regulator on a D45B or C dynamo, nor is it possible to use the F regulator on dynamo type D45D.

The minimum voltage-setting figure is obtained from the type symbol in a manner similar to that described for the BJ and BK regulators, the tolerance in the case of the BG being plus 0·5 and 0·2 volt for the 12-volt and 6-volt machines respectively. Cut-out voltage is set at 1·5 to 4 volts below the minimum regulator setting for 12-volt D45D dynamos, and 1 to 2·5 volts down for 6-volt machines.

Electrical settings should be carried out with the dynamo running at approximately 1,000 r.p.m.

Cut-out Mechanical Setting

(1) Slacken off screws (*AA*) attaching flat springs to the armature frame (*see* Fig. 20).

(2) Insert 0·25-mm. feeler between the armature and frame.

(3) Press down the armature on to core and back against feeler so that the feeler is gripped firmly.

(4) Tighten screws (*AA*) holding the flat spring.

(5) Set air gap between armature tip and core from 0·9 to 0·95 mm. when contacts are open. This can be adjusted by bending strip (*AB*).

(6) Set contact gap from 0·3 to 0·35 mm. when contacts are open, by bending contact strip.

Cut-out Electrical Setting

This is carried out by bending the brass strip (*AC*), which is in contact with the cut-out auxiliary spring.

Regulator Mechanical Setting

(1) Slacken off screws (*AD*) attaching armature flat spring to frame.

(2) Insert a feeler 0·15 mm. thick between armature and frame.

(3) Press down armature on to core and back against feeler so that the feeler is firmly gripped.

(4) Tighten screws (*AD*) attaching armature to frame.

(5) Set air gap between armature tip and core from 0·6 to 0·65 mm. when the contacts are closed. This adjustment can be made by bending the fixed contact bracket (*AE*).

Regulator Electrical Setting

This is adjusted by the control screw (*AF*), which sets upon the auxiliary spring.

Separate Unit Cut-outs

The cut-out is a very necessary part of the electrical equipment, in order to prevent the battery discharging through the dynamo when the dynamo is at rest, or when the speed of the dynamo is too low to generate a sufficient pressure to overcome that of the battery.

The contacts of the cut-out are open when the dynamo is at rest or running at a low speed, so that the direct connection between the dynamo and battery is broken.

As the dynamo speeds up and eventually reaches the cutting-in voltage of the cut-out, the windings of the cut-out magnetic core are sufficiently energised to attract the steel armature and close the contacts. The connection between the dynamo and battery is, therefore, completed and will remain so until the dynamo speed falls below cutting-out speed and the contacts reopen.

Cut-outs—Types 4 and 4G

This cut-out is fitted with a laminated main contact together with auxiliary carbon contacts, the latter being arranged to make before, and break after, the main contacts.

The moving armature hinge-pin should be lubricated occasionally with thin machine oil.

Contact faces should be kept clean with very fine carborundum paper or a fine file, care being taken to keep the faces perfectly flat and square with each other. Emery or coarse grit should not be used for this operation.

Replace the contacts, if the laminations are burnt so that they will not spread or their faces are badly pitted.

Do not alter the tension of the armature spring.

Cut-out—Type No. 7

This is a heavy-duty unit fitted with a large laminated moving contact.

Maintenance details are the same as given for types Nos. 4 and 4G.

The position of the stop-screw should not be altered.

Cut-out—Types DR, DR1, and DWO

All these types are similar in construction, the essential differences being only as follows:

Type DR—Terminals marked 5 A.1 insulated return.

Type DR1—Terminals marked 5 A.1 insulated return for use with DBLR and DBLN dynamos.

Type DWO—Terminals marked 5 A.1 insulated return, diagram marked in cover.

Adjustment of Cut-outs

All cut-outs dispatched from the factory have been thoroughly tested and adjusted to work in conjunction with their respective dynamos. After considerable use it may be necessary to readjust the cut-out to the following particulars (*see* also Fig. 21) :

Contact air gap : ·020–·025 in. (·5–·63 mm.). Adjustment is possible by carefully bending the moving contact strip arms.

Air gap between the core and armature with the contacts closed : ·010–·015 in. (·25–·38 mm.). Adjustment is effected by removing one or more packing shims (*N*) clamped between the core and frame. In order to do this it is necessary to first remove the armature (*D*) and fixed contact strip (*M*) with the terminal block (*K*), after having extracted the fixing and terminal screws (*L*) (*P*) (*Q*). The core, with its bobbin, can then be easily taken from the frame, after removing the fixing nut and washer (*R*).

The reverse current should not exceed 2 amps. on the 6-volt, and 3 amps. on the 12-volt cut-out.

By turning the nut (*J*), the voltage at which the cut-out operates can be adjusted to suit the dynamo it is to work in conjunction with.

Setting for 6-volt machines should be 6·5–7·0 volts.

Setting for 12-volt machines should be 12·25–12·75 volts.

After having made the necessary adjustments, care should be taken that the nut (*J*) is firmly in position against the curl of the soldering tag, in order to prevent it from turning due to any exterior vibration.

Maintenance of Cut-outs

The contact points should be periodically examined for corrosion or dirt. They may be cleaned with spirit or very fine carborundum paper, but do not use a file or any form of coarse grit.

If the contacts are in a burnt or pitted condition they should be replaced. To replace them it is necessary to remove the whole contact strip as, owing to the size of the contacts, they are supplied already riveted to the strip. The contact strips can be removed by extracting the respective fixing screws (*P*) or (*Q*). Take care to replace the insulating pieces and bushes in their correct positions.

The bobbin windings should on no account be touched. If any fault is located or suspected, the cut-out should be returned to the manufacturers to be rewound or repaired.

JACKALL JACKING SYSTEM

MAINTENANCE AND SERVICE

By DENYS H. SESSIONS

OF the several types of jack and jacking system fitted both as standard and as optional equipment to the car of to-day, it may generally be said that in the event of trouble the simplest and wisest course for the repairman is to return the faulty unit under the respective manufacturer's scheme for advance service. This is not so, however, in the case of the Jackall inbuilt jacking system, and the following remarks are intended to serve as a guide to the repairman who is presented with the problem of a quick cure and who receives little more by way of assistance from the customer than the somewhat vague statement: "My jacks won't work!"

The System Explained

In the first place an understanding of the system is essential. Operated on the hydraulic principle, the Jackall system consists of three main components: the Fluid reservoir, the Distributor and Pump, and the jacks. Connecting these there is a system of piping, and by virtue of the fact that part of the system is mounted on the frame and coachwork and part on the axles, some form of flexible connection must form a part of the piping arrangements.

Operation of the pump by means of the operating handle has the effect of transferring fluid from the fluid reservoir to the jacks under pressure. The jacks are thereby extended, and being rigidly attached to the car axles they have the effect of lifting the car upwards until the full extent of their travel is reached.

By means of the distributor it is possible to transfer fluid to all the jacks or to only front or rear, as may be desired.

To lower the car it is necessary only to open a release valve which allows the fluid to escape from the jacks back into the fluid reservoir. When the weight of the car is off the jacks these continue to retract owing to the internal return springs fitted.

Operation

To operate the Jackall system, it is necessary first to procure the handle, which may be clipped to the bulkhead beneath the bonnet, under the fascia, or in the tool-box. The pump and distributor unit may

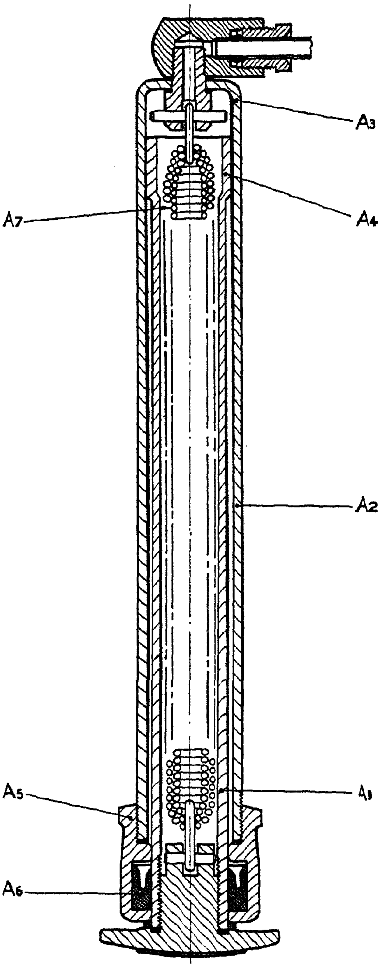


Fig. 1.—SECTION THROUGH THE JACK
(*Smith's Jacking Systems, Ltd.*)

be fitted under the bonnet or, as in most cases, under the floorboards beneath or in front of the passenger's seat, in which event the floor covering should be rolled back to expose the trapdoor covering the unit. The handle should be applied to the spigot identified with a *D* on Fig. 2, and worked to and fro. Before the pump is effective, however, it is necessary first to close the release valve by screwing down the bakelite knob (*P*) and to select "front," "rear," or "all" jacks by moving the selector (*Q*) to the required position.

The operator will know that the respective valves are closed correctly as soon as he starts to oscillate the pump handle. If everything is correctly set, a slight resistance will be felt on the handle, which will slightly increase as the jacks make contact with the ground, and a very greatly increased resistance will be felt when full extension of the jacks has been reached.

At this stage, of course, there is no further object in continuing to pump, but a pressure-relief valve is incorporated in the system so that no harm can result if the operator should for any reason endeavour to continue pumping after this stage. To lower the car, it is necessary only to unscrew the bakelite release-valve knob (*P*) one complete turn, when the car will drop to the ground and the jacks will automatically return into their housings. The suddenness with which the car is lowered depends, of course, on the sudden or gradual unscrewing of the release valve.

Important

When the system is out of use make sure that the release valve is open (i.e. unscrewed in an anti-clockwise direction at least one turn). When

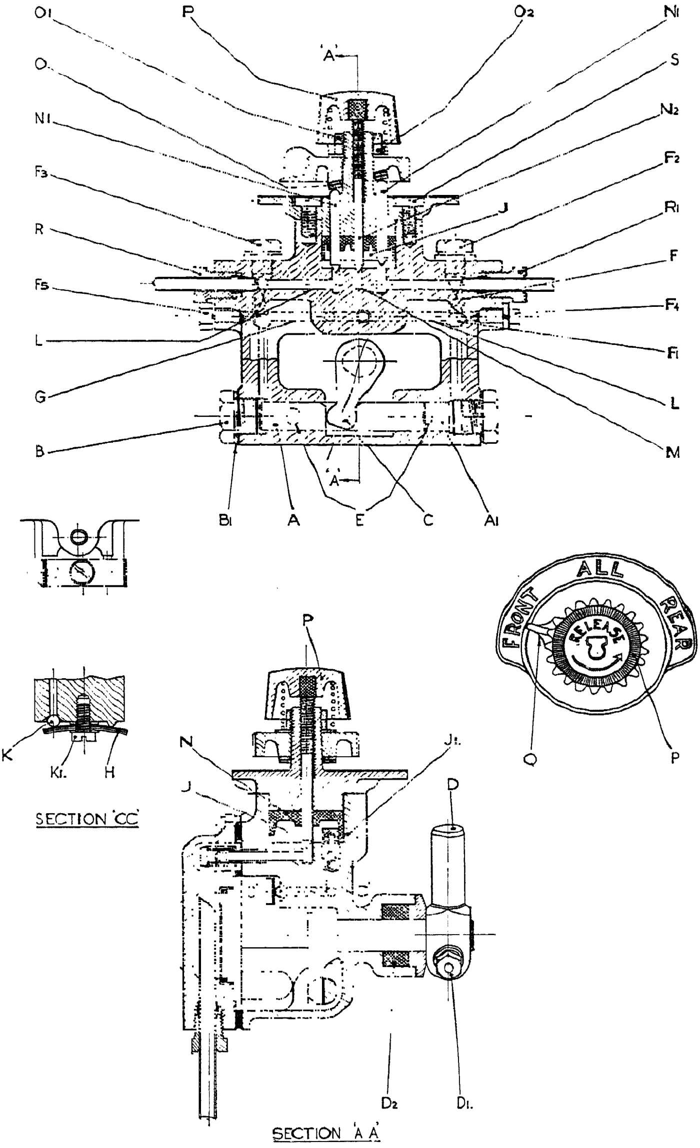


Fig. 2.—DISTRIBUTOR AND PUMP UNIT

"topping up" the fluid reservoir make sure that all the jacks are fully retracted, and fill up only to the mark on the reservoir.

Use only Jackall Fluid

This is imperative, as almost any other fluid will have disastrous effects on the rubber parts of the system and a complete strip down will be necessary. In addition, the use of any other fluid automatically cancels the manufacturer's guarantee.

If it is desired to leave the car for some while with the weight off the tyres, it is advisable to jack up and then lower the axles on to suitable props (one or two bricks will do). Do not leave the car jacked up longer than is necessary, as the pipe lines and joints are subject to considerable pressure when the system is in use.

Finally, make sure that the system is operated at least once a month. This will ensure that the fluid is kept in good condition and the parts well lubricated. No further attention should be required other than an occasional "top up" with Jackall fluid.

The Distributor and Pump Unit

The distributor and pump unit (*see* Fig. 2) consists of a special-alloy casting in which a double-acting plunger (*A*) oscillates in the cylinder (*A*1) and is ground to a perfect fit. It should be noted that no packing is used on the plunger. At the extremity of each cylinder there is a cylinder end cap (*B*) sealed with a copper washer (*B*1). A forged crank lever (*C*), which drives the plunger to and fro, is fitted with a lever (*D*) on to which the operating handle fits. This lever is keyed on to the crank spindle by a special chrome-nickel steel cotter, and it should be borne in mind that replacement of this part with an ordinary cycle cotter is not satisfactory.

Oscillation of the pump plunger alternately uncovers the ports (*E*), through which fluid is sucked from the supply tank, and sends it under pressure through the delivery ports.

It will be noted that where low-pressure leakage is possible, i.e. along the crank-lever bearing, an effective seal is made with a moulded composition gland (*D*2). There is no possibility of failure on the inlet side of the pump, provided the ports are not clogged, as there are no spring-loaded or other type of valves to cause trouble.

The delivery valves are simply balls (*F*1) controlled by square-section gravity weights (*F*), which also serve to limit the travel of the ball to $\frac{1}{16}$ in.

After passing the delivery valves the fluid enters the passage (*G*), and into this passage the pressure-relief valve (*K*) is introduced. As will be seen, this takes the form of a spring-loaded $\frac{7}{32}$-in. ball which is automatically set at the correct pressure, provided the screw (*K*1) is tightened securely, and of course comes into use only if excess pressure is generated

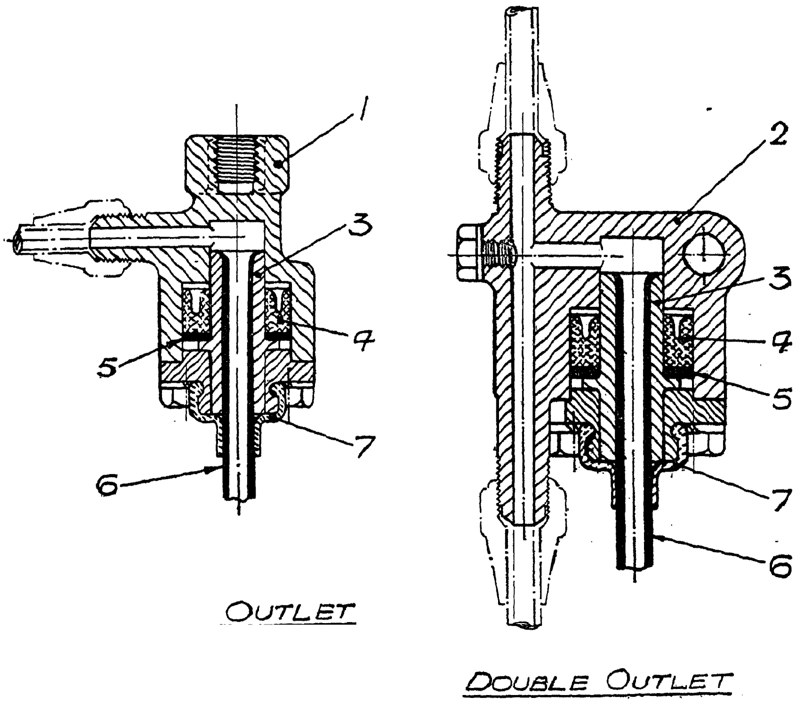


Fig. 3.—JUNCTION BOXES

in the pump. The fluid passes through the master check valve ($J1$) into the chamber (J). This valve is provided to ensure no return of fluid to the pump, and relieves the delivery valves and safety valve of any duty other than their normal function.

A filter is provided in the back-cover plate, and the fluid passes through this at each operation.

In the base of the chamber (J) there are three openings, two of which (L) serve the front and rear jacks, the third (M) providing a return for the fluid after use.

The top of the chamber (J) is sealed by a moulded rubber bucket valve through which pass three valve spindles, the conical ends of which serve to close the three ports in the base of the chamber.

The centre valve ($N2$), which controls the return of fluid through the unit, is screwed down by turning the bakelite release knob (P) which is moulded on to the spindle. The other two valves, (O) and ($N1$), controlling flow to the jacks, are depressed by the selector (Q), the underside

of which acts as a cam. Thus by turning the selector to the desired position the two valves (O) and ($N1$) are pushed down or allowed to rise, as the case may be.

It will be appreciated that before operation the release valve must be closed, otherwise the fluid would simply circulate along the line of least resistance, back to the reservoir.

To prevent turning of the release valve when in the open position, a light coil spring is inserted beneath the bakelite knob (P).

The Jacks

Each jack is composed of an inner and outer steel tube ($A1$) and ($A2$). The outer unit is domed at one end to form a cap through which there is a hole for the spring anchorage, and threaded externally at the other end to take the gland housing (Fig. 1).

The inner tube is bulged at one end to form a bearing in the outer tube, and threaded internally to take the foot at the other end. Inside the inner tube there is a very strong coil spring, anchored at one end to the foot and at the other to the top anchorage, which is attached to the outer tube. Thus it will be seen that the spring tends to keep the inner tube retracted into the outer tube.

To extend the jack, fluid is forced through the top elbow fitting into the spring compartment, thereby causing the inner tube to move outwards.

In the gland housing which is fitted to the end of the outer tube there is a moulded rubber bucket so designed as to prevent any leakage of fluid whatever down the outside of the inner tube.

Special Flexible Unions

Where it is necessary to convey fluid from the pump or the frame to the jacks on the car's axles there has to be provided some form of flexible coupling.

For this purpose steel pipes are used in place of the normal copper piping, and at each end these are connected to special unions (*see* Fig. 3). On the frame a single outlet union is used, and on the axle a double-outlet union caters for the distribution of fluid to both jacks.

These unions consist of die-cast housings (1) and (2), into which a pipe is fitted with a special bush (3) so shaped as to be gripped by a moulded rubber bucket washer (4), which is so designed that the pressure of the fluid serves to increase the effectiveness of the seal. The thrust is taken by a loose washer (5). On the outer end of each joint there is a rubber cap to prevent ingress of dirt or moisture.

Pipe Connections

There are two types of connection used in the pipe line, these being of the external- and internal-sleeve type.

In the case of the flexible unions it will be seen from the illustration

DIAGNOSIS AND TREATMENT OF FAULTS

Pump

Faults	*Diagnosis*	*Treatment*
(1) Pump not operate	No fluid in reservoir. Loose cotter pin, blowhole in casting, broken safety-valve spring, release valve not seating, airlock, vent holes in reservoir cap choked.	To ensure there is no airlock, slacken off either valve cap (*F*2) or (*F*3) above delivery valve three or four turns, operate pump for at least 60 secs. If no fluid appears, pump must be dismantled and trouble located.
(2) Works on one cylinder only	Travel of operating handle restricted on one side.	In order to allow fluid to enter cylinder it is essential that a full stroke be given to the pump in each direction. It sometimes happens that an adjustable seat, fixed too far forward, or other obstruction, fouls the handle and prevents this.
(3) Will not retain pressure	Defective casting, faulty master-check valve, faulty release valve or valve seat, external leakage in system	Dismantle distributor box, carefully examine all valve seats and valves, removing master valve, retaining ring, and valve (*K*). If no defect is apparent and there is no external leak, casting is faulty and should be replaced.
(4) Will not lower car when release is operated	Foreign matter in release-valve duct, release valve faulty	First of all lower car by unscrewing joints (*R*) or (*R*1) three or four turns, allowing sufficient fluid to escape so as to enable the jacks to return to a fully closed position. Under no circumstances must screws (*S*) on indicator plate be interfered with until the jacks have returned fully home. Remove indicator plate, remove valve unit, fit new valve unit, and reassemble. If trouble persists, pump should be removed, dismantled, and thoroughly cleaned. Care must be taken that all passages and ducts are free. To reset indicator (*O*) adjust nuts (*O*1) and (2) until the pointer is able to move 20° freely on each side of the "all" position and a slight resistance felt when the pointer is turned to (*F*) or (*R*). The indicator should be set so that little effort is required to move it to any desired position.
(5) Jacks return very slowly when release is fully open	Operating pins (*N*2) too tight in cap	Usually caused by corrosion. Remove indicator plate, remove pins, clean and oil thoroughly with castor oil, and replace.

DIAGNOSIS AND TREATMENT OF FAULTS—(*continued*)

PUMP

Faults	*Diagnosis*	*Treatment*
(6) Works on one side of indicator but not on other, or "All" position	Defective casting or one faulty valve	Remove valve bucket (N) and examine valve seats and valves carefully. Replace bucket if necessary. If fault persists, casting is faulty.
(7) Leaks at indicator plate	Defective casting or faulty valve bucket.	Remove valve bucket (N), examine for puncture, replace bucket if necessary. If fault persists, casting is faulty.
(8) Leaks under pres-	Cylinder-end cap (B) or other caps loose ($F2$), ($F3$), [illegible]	Without removing unit from chassis, go over all plugs with spanner to ensure tightness, wipe box thoroughly. If leak persists, a new copper washer will probably effect a cure, wipe thoroughly, then operate all four jacks, pumping ten or twelve strokes against safety valve, then examine the various plugs.
(9) Leaks slow drip	Cover-plate screws loose, or faulty gasket	Remove unit from chassis and tighten screws thoroughly, do not disturb cover plate unless absolutely necessary. If cover plate is removed, a new washer must be used, all faces thoroughly cleaned, and Seccotine, Croid, or similar adhesive used on both sides of washer.

FLEXIBLE HYDRAULIC COUPLING

Faults	*Diagnosis*	*Treatment*
(1) Leak at hydraulic joints	Plug on double outlet loose, or faulty copper washer, fault in casting, faulty rubber buckets, faulty brazing	Tighten plug, fit new copper washer if necessary, examine rubber bucket. If leak appears through rubber dust cap, brazing is faulty.
(2) Leaky pipe	Split or damaged externally	Must be replaced by pipe, complete with end bushes, cover plate, and rubber dust cap.

DIAGNOSIS AND TREATMENT OF FAULTS—(*continued*)

JACKS

Faults	*Diagnosis*	*Treatment*
(1) Failing to return after use	If either pair or all jacks fail to return, fault is due to defective valve in distributor box or choked pipe. If one jack fails to return, broken spring, bent or distorted ram	Remove jack, first turning indicator on distributor box to opposite side. Grip in vice (using shaped hardwood blocks), remove elbow. Remove bottom cap; ram can then be withdrawn. Remove spring anchor pin, grip ram in vice (again using shaped blocks), remove foot to which spring is attached. Check ram for straightness or distortion, check spring. When reassembling, new copper washers should be used.
(2) Leak at foot	Faulty copper washer or foot loose	Remove jack. Without dismantling, ram can be pulled out and gripped in shaped blocks for retightening.
(3) Leaks at screwed part of bottom	Faulty copper washer or cap loose	Remove jack, grip in blocks, retighten if leak persists, jack should be dismantled and new copper washer fitted. Great care must be taken to prevent cap being distorted by undue force when reassembling.
(4) Leak at elbow	Elbow loose or faulty copper washer	Without removing jack from bracket, remove union nut, remove elbow and examine copper washer and replace if necessary, ease off bracket to enable elbow to be turned into line with pipe, and retighten.
(5) Leak past gland	Faulty rubber bucket. Bottom cap damaged or distorted, "swarf" or other foreign matter lodged between bucket and ram	Dismantle jack, prise out bucket with blunt tool, examine for faults, examine inside of annular groove for dents or distortion. Bucket housing or bucket to be changed if distorted or faulty in any way.

that the delivery ends have a conical face and are threaded externally. In this type of connection the copper pipe must be belled out to go over the conical face and the external sleeve then tightens the copper on to its seating.

The internal type of sleeve as used elsewhere in the system and illustrated in Fig. 1 against letter (R) employs an "olive" to grip the pipe. When the sleeve is tightened into its housing the "olive" (a brass ring with double conical face) bites into the copper pipe and effects a perfect seal.

Both types of joint may be used many times without renewing.

DISMANTLING

Distributor and Pump Unit

If the unit is to be removed, disconnect supply pipe from tank and plug or drain into suitable receptacle. See that jacks are fully retracted.

The valve bucket (*O*1) may be removed without loss of fluid, but take care to cover valve chamber so as to prevent entry of dirt.

Carefully filter all fluid reintroduced into the supply tank.

After assembly the system may be " bled " by slacking off one of the jack connections until fluid is forced through.

Jacks

See that jacks are fully retracted and selector pointing to opposite pair of jacks.

Plug pipe ends to prevent entry of dirt. Do not wash jacks with petrol or bring into contact with mineral oil. Methylated spirits may be used for cleaning, after which moving parts should be smeared with Jackall fluid.

REPAIRING LUCAS HORNS

By E. T. LAWSON HELME

ELECTRICALLY-OPERATED horns fitted to road vehicles may be classed in two groups, the largest of which includes all those having a thin metallic diaphragm as the sound-producing element. The remainder are reed-operated, air pressure being maintained by an electrical compressor.

Among the diaphragm horns, the original low-frequency pattern is now obsolete and seldom encountered, but the high-frequency design is almost universally employed. The ruling principle of this type is the rigid coupling of the diaphragm and magnet plate, or armature, and this, in conjunction with the contact-breaker setting, enables the characteristic penetrating note to be produced. Fig. 1 illustrates the operating principles of a high-frequency horn.

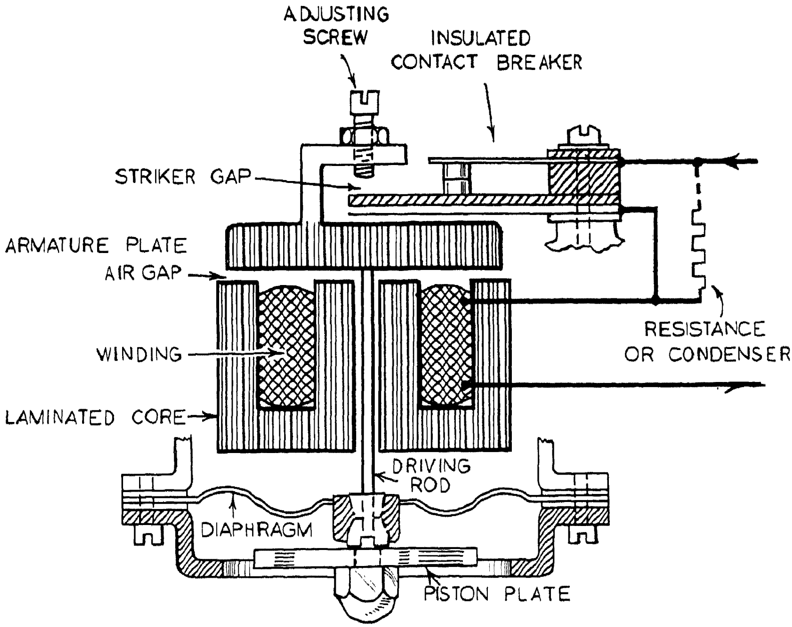


Fig. 1.—ILLUSTRATING PRINCIPLES OF HIGH-FREQUENCY HORN

Construction and Operation of High-frequency Horn

The hollowed iron core, on which the coil is fitted, is, along with the iron armature, of laminated construction. Thin stampings of the required shape are assembled by riveting together in packs, while a film of insulating varnish between adjacent stampings insulates surface contact. Eddy currents generated in the iron are thus reduced to a minimum, and heat losses which might result therefrom are reduced accordingly. The magnetic lag which would result from the use of a solid iron construction is largely eliminated, and the rapid rise and collapse of flux, essential to correct functioning, is greatly facilitated by this method.

The Diaphragm

The diaphragm is a specially heat-treated and tempered steel pressing, its edge being clamped between the body and rim of the horn by screws. Paper gaskets on each side ensure a degree of elasticity in mounting.

The centre of the diaphragm has a screwed boss to which the driving rod is secured. A slotted conical nut, with locknut, is fitted to some models for adjusting the position or relative length of the rod. The rod passes through the hollowed core and is rigidly secured to the armature, which is suspended by a light flat spring, so that a small air gap separates its inner surface from the surface of the core.

A contact-breaker, comprising a spring blade with contact tip bearing against the fixed contact tip in the bracket, is fixed so that a striker bends the blade and separates the contacts when the magnet assembly is energised by the solenoid and attracts the armature towards it. The speed at which the moving section, including armature, driving rod, and diaphragm, vibrate is governed by the natural frequency of the diaphragm according to its diameter, thickness, and flexibility.

A circular plate fitted outside the diaphragm, and free to move with it, also exerts a considerable influence on frequency. Known as a "piston plate," this disc acts as a buffer or frequency stabiliser in that it meets a cushion of air on each inward and outward stroke. Its mass introduces a certain inertia which is further instrumental in this respect. Electrical characteristics are improved and sparking reduced by the damping effect of a resistance winding or condenser connected across contacts.

The contact-breaker and winding are in series, and must be fully insulated from the horn body and from each other.

Air-gap Adjustment

Two adjustments are incorporated. One is the air-gap or length of driving rod, usually effected by a screw in the diaphragm boss. This is set by the makers to allow the maximum efficient amplitude of vibration with a minimum air-gap and should not be disturbed.

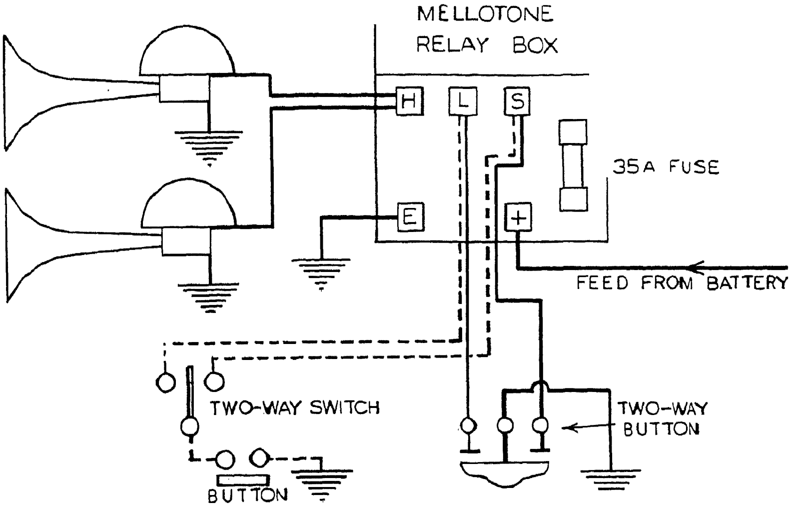


Fig. 2.—MELLOTONE CIRCUITS
Showing alternative switch-button layouts.

Contact-gap Adjustment

The second is the contact-gap, or rather, the degree of inward movement of armature towards core before contacts separate. In Lucas Model H.F. 722, Altette, and similar horns, an exterior screw-head with locking serrations is provided for altering this adjustment, the best position being found by trial.

Cracked Diaphragm

If the horn will not respond to adjustment and gives only a reedy or rattling note at best, the diaphragm may be cracked.

Shorted Contacts and Earthed Winding

A single " clack " on making contact indicates armature striking magnet-pole face, and if this is not corrected by turning the screw clockwise, the probable cause is shorted contacts or earthed winding.

Open Circuit in the Horn

Open circuit in the horn may be due to faulty adjustment, or to a break in winding or terminal connections.

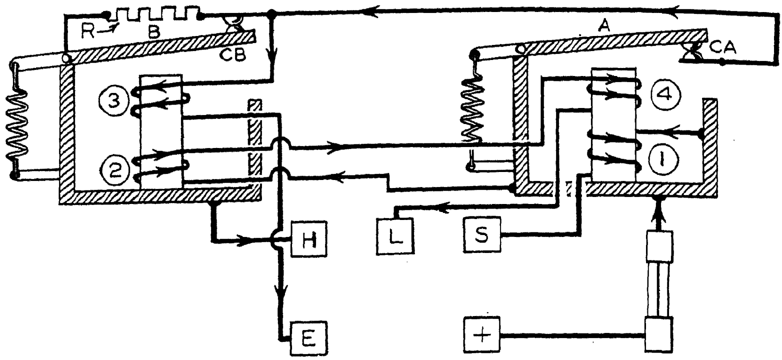


Fig. 3.—CIRCUITS OF MELLOTONE RELAY BOX

Mounting the Horn

The note of a high-frequency horn is influenced to some degree by the mounting bracket. Various designs are in use, including leaf-spring attachment, rubber bushing, or suspension, and solid two-point attachment. The bracket should be securely fixed, and the horn body must not bear against surrounding metal or cables. The latter should have enough free length to allow a certain amount of body movement without tension.

Wind-tone Horn

A modern development of high-frequency practice is the wind-tone horn, in which diaphragm movement is tuned to correspond to the natural frequency of the air column in the trumpet. When correctly adjusted, the note approximates to that of an efficient reed horn, the air vibration being directly generated by the diaphragm. Construction is largely similar in design, but adjustment is critical and must be carefully executed.

Twin-horn Sets

In both Mellotone and Post Horn sets, a pair of specially tuned horns, producing harmonic note combinations, is operated, through a relay switch in the case of the Mellotone, and direct via push in the Post Horn set. The horn mechanism is enclosed by a dome, secured by a central screw, removal of which gives access to contact-breaker and adjustment.

The Mellotone Horn Set

In the Mellotone horn set the choice of a loud or soft tone is provided by the relay unit and two-way switch or button. Fig. 2 is a circuit

diagram of the Mellotone layout. Two relay solenoids are fitted on a moulded base, together with terminals and fuse. When the button or switch-button combination is closed in "loud" position, the operating solenoid is energised and contacts meet, when full-voltage is applied to the horns. The resistance solenoid, contacts of which remain closed, is not energised, and its contacts bridge the resistance. When the circuit is closed in "soft" position, both solenoids operate, the operating unit closing main circuit to horns, while the resistance unit opens its contacts and, the resistance then being in circuit, voltage on horns is reduced and a soft note results. Each solenoid carries two windings, one pair supplementing and the other pair opposing each other.

Fig. 3 shows the internal circuits of the Mellotone control box, and operation is as follows:

When a circuit to earth is established from terminal (*L*), via push or switch-push combination, current flows from fuse to windings (2) and (4) in series, to terminal (*L*) and thence to earth.

Both relays (*A*) and (*B*) are momentarily energised, but immediately relay (*A*) closes, contacts (*CA*) meet, and current flows thence to winding (3) and terminal (*E*) to earth. The flux of winding (3) opposes and cancels out the flux of winding (2), so that relay (*B*) remains closed. Current therefore passes from contacts (*CA*) to contacts (*CB*), via frame of relay (*B*) to terminal (*H*) and cables to horns, giving "loud" note.

If the "soft" button is pressed, current flows from fuse to frame of relay (*A*), winding (1), and (*S*) terminal to earth. Contacts (*CA*) close and current flows to winding (3) and terminal (*E*)—earth. Relay (*B*) is energised, contacts (*CB*) are drawn apart, when the resistance (*R*) is inserted in the feed circuit to the horns, producing a "soft" note.

The design of wind-tone horns necessitates the provision of a trumpet of correct length and shape. The reason underlying this is that the natural frequency of the air column contained in the trumpet must correspond to that of the moving system, comprising diaphragm and armature plate. The characteristic tone of the horn depends on this factor. In units of the "post horn" type, where a short flare is fitted, the necessary exponential column length is obtained by a spiral passage formed in the base.

This method is applied in later type Mellotone sets, replacing earlier designs with straight trumpets.

SERVICE INFORMATION

Horn Circuit

Single horns and twin sets operated direct through the button may be connected to a fuse fed via ignition switch or fed direct from ammeter, according to the year and model of car.

Short to Earth

The button is in the earth side of the circuit, so that a short to earth in any part of this section will result in constant horn sounding until fuse is withdrawn or ignition switched off.

Blown Fuse

A short in the feed section to the horn will blow the fuse. The circuits of the horn itself must be insulated from earth, as each terminal has the same effects in the case of a fault as the section to which it is connected. It is immaterial to which terminals the wires are connected, but insulation is important.

Position of Horn

Special attention is advisable where the horn occupies a position exposed to rain. When new horns with flares are to be fitted, the trumpets should be horizontal or inclined slightly downwards so that water cannot collect in them.

Connections

In some models the cable connections are made by small ferrules soldered to the cable ends and inserted into spring clips. The soldered joints in these ferrules should be checked, as also the joints made in any rubber-sleeved push-in connectors in the wiring.

Use of Horn Relay

One of the main objects of the relay box is to shorten the main circuit to the horns and thereby avoid voltage drop. The button and wiring from relay box—including that passing through the steering column section—only carries the small relay winding current, the main circuit via the contacts being direct. Mellotone horns must not be wired other than through the proper control box, and it is advisable to fit a relay unit with any twin set unless this is definitely unnecessary, as in the case of horns with small current consumption.

Adjusting Contact-breaker

Adjustment of contact-breaker unit is usually provided for by a screw with locknut. It is essential to securely lock the screw, as vibration is liable to slacken it. Vibration also affects brackets and mountings.

Wherever possible, only the brackets provided with the horns should be used in fitting, but if special mountings have to be made they should be amply rigid and should be designed to support the horn against the vibrational stresses imposed in any one direction by the balance of weight. As mentioned earlier, the horn must be clear of obstructions or contact with the mass of the vehicle other than through the bracket.

This applies in particular to fitment under the bonnet, when contact with the bonnet when closed, or the movement of the engine in rubber mountings, must be reckoned with.

Electrically Operated Reed Horn

The Lucas-Spartan Bugle-Chime horn is an interesting example of the electrically operated reed horn. A small motor drives a flying-vane air compressor, the air from which is fed via valves to three separate reed-diaphragm trumpets tuned to a musical chord. The motor also drives, through reduction gearing, a camshaft with three cams which open the valves to the trumpets in sequence, resulting in a repeated bugle-call. A relay device ensures that the unit continues running until the call is completed, even though the button is released prematurely. A two-way switch is provided which operates a solenoid in addition to the motor, the solenoid, when energised, holding down all three valves so that a chord is sounded.

Wiring up Additional Horn

It should be remembered when fitting special or additional horns that it is unwise to disconnect the existing button in favour of a special button which may be necessary, as the driver will probably have formed a habit of unconsciously using the old button and will do so in emergency. It is usually practicable to wire a change-over switch through the existing button, or, where a new control—such as a Mellotone two-way button—is fitted, the old horn control should be left complete.

Hints on Tracing Faults

Amongst points worth noting in tracing faults in horns and circuits, the following should be observed :

Loss of volts due to the resistance of oxidised push contacts, defective wiring or connections, or a weak battery may be a misleading factor. Avoid disturbing the horn adjustment until proved necessary by a test on an independent circuit.

The best check on circuit conditions is to connect an accurate voltmeter to the horn terminals, noting the reading when the horn is sounded. Complaints of a strident, ill-tuned note have been found to arise from the basic cause of a maladjusted regulator, which overcharged the battery and consequently boosted its voltage to an abnormal value. Modern H.F.-type horns are sensitive to voltage variation, and a check on this is always advisable.

Twin horns, operated through a relay, should be wired direct from the battery terminal of the starter switch, or other convenient main terminal. Most relay units incorporate a fuse, failing which a separate fuse-holder should be fitted.

Where twin horns are wired direct to the battery voltage supply, it is advisable to see that auxiliary fuses are not overloaded. The horns can be wired to separate auxiliary fuses in order to divide the additional load, using a common push-button and return wiring, provided that the two fuses are supplied from a common battery point.

COAL GAS AS SUBSTITUTE FOR PETROL

By C. R. B. SMITH

COAL gas was used fairly extensively during the last war, mainly on commercial vehicles and hackney-carriages.

The method used was of the "low-pressure" variety, and consisted of a fabric envelope, usually carried on the roof of the vehicle, which contained the gas. The main objections to this method are the offering of extra wind resistance by the large envelope on top of the vehicle and the limited operational radius of the gas which can be conveniently carried. The former can, of course, be overcome by the usage of a trailer to carry the gas envelope, but the latter objection still remains.

As a rough guide, approximately 12 cu. ft. of coal gas at between 450 and 550 B.Th.U.s per cubic foot should be reckoned per mile. This, of course, being for, say, a 12-h.p. engine, and will vary accordingly.

The other, and better method, is the usage of "high-pressure" gas stored in steel cylinders, but this will be dealt with later on in this article.

LOW-PRESSURE GAS SUPPLY

Mixture Control

In this case, a simple type of suction-operated valve can be used to control the gas supply, the flow of main air causing the valve to lift and admit gas. The mixture strength can be governed by using a taper needle, the taper characteristic controlling the mixture strength at any given throttle opening.

An alternative system is to govern the mixture strength by means of an air shutter or butterfly valve on the air intake. This mixing valve, when in a state of rest, cuts off the gas supply from the container.

It is usually necessary to have a separate gas supply, viz. an adjustable cock or tap for the slow-running system, as the volume of air used is not sufficient to operate the main gas valve. This "idling" or by-pass gas supply can with advantage be led adjacent to the dashboard of the vehicle, so that the slow-running supply can be regulated from the driving seat, and, of course, should be turned off when the engine is switched off.

Feed from Gas Container

The feed pipe from the gas container to the "mixer" should be kept

as large as possible, to ensure an immediate response in flow when occasion arises.

By-pass Adjustment for Slow-running

The by-pass adjustment for the slow running previously referred to should be marked so that the correct adjustment can be immediately arrived at, or, better still, a master tap should be fitted in addition to the adjustment, so that the idling supply can be turned off without upsetting the final adjustment.

Starting the Engine

When starting the engine, after having opened the idling gas supply, the accelerator pedal should not be depressed in any way until the engine has fired, as this will lead to an over-rich mixture being admitted, which will retard starting.

Proportion of Air to Coal Gas

The correct proportion of air to coal gas for proper combustion is in the neighbourhood of seven volumes of air to one of coal gas for maximum power, and as lean as ten volumes of air to one of coal gas for maximum economy.

Power Obtained on Coal Gas

The power obtained on coal gas may vary between 60 and 80 per cent. of that obtained on petrol, varying with the individual engine design. Any " hot-spots " in the induction system, for instance, result in a lower volumetric efficiency, with a corresponding decrease in power.

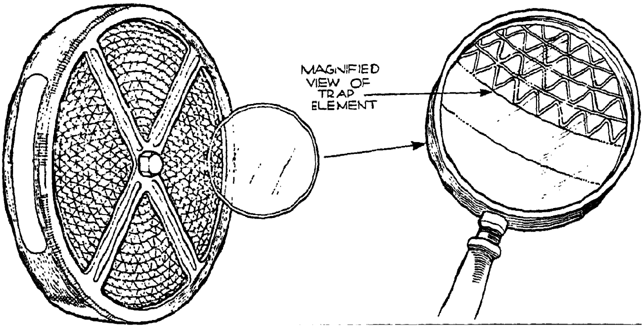
HIGH-PRESSURE GAS SUPPLY

Mileage Obtainable

With this layout a much larger operational radius can be obtained, as the gas is stored in steel cylinders which can be charged to a pressure of 3,000 lb. per square inch, resulting in a large volume of gas being stored in a small space. The average size of cylinder charged at this pressure holds about 300 cu. ft. of gas, so that this means about 25 miles, roughly speaking. It will thus be seen that with eight of these cylinders stored either under the body, in the case of a lorry, or in a trailer on a private car, the mileage possible is appreciable.

Pressure-reducing Valve

A high-pressure reducing valve must be used, which breaks down the 3,000 lb. per square inch to atmospheric, either in one or two stages, the



THE AMAL FLAME TRAP

volume flow being, of course, controlled by engine suction. The reducing valve, in the case of one, or the final valve in the case of two, should be suction-operated, so that any leakage of gas is prevented when the engine is not running.

Mixer for High-pressure Gas

A representative type of mixer for high-pressure gas consists of a gas inlet from the reducing valve in which is situated a flame trap (this will be described later), and then via a plate orifice to slots in the choke tube. The gas then mixes with air passing through the choke tube, and the final volume of mixture is controlled by a butterfly valve. The amount of gas passed to the slots in the choke is governed by the plate orifice.

Again, in the case of high-pressure gas, the slow-running arrangements are as for low-pressure gas, and consequently a by-pass must be fixed up from the reducing valve to supply the idling mixture, as previously explained. The necessary variations in mixture strength are obtained by combinations of choke tube and plate orifice, regulating air and gas supply respectively.

Safeguarding against Fire Risk due to Blow-back Flame

Reference has been made to the usage of a "flame trap" or "flame arrester" in the gas-supply line; and this is to safeguard against fire risks due to blow-back flame. A well-known example of this is the Amal flame trap, which consists of an alternate plain and crimped ribbon of thin metal wound from a central pin into a circular "trap" of any required diameter. This gives a unit which has a depth of $\frac{3}{4}$ in., and, due to the crimped formation, offers a large cooling area to a flame attempting to pass through, in relation to its frontal area. As a result, the flame is

definitely damped out before reaching the other side of the trap, while at the same time resistance to air flow is negligible.

The importance of incorporating one of these flame traps somewhere in the gas-supply pipe line will be appreciated.

Fitting a Flame Trap

When considering the fitting of a flame trap the required flow of gas at full throttle should be known in cubic feet per hour; then, if this figure is given to the flame-trap manufacturers, they can supply a trap which will offer the minimum resistance to flow, with the maximum efficiency as a flame trap.

ADJUSTING ENGINE FOR RUNNING ON COAL GAS

Now a few words about possible engine adjustments to suit gas as a fuel. It would seem that in most cases a slight power increase can be obtained by somewhat increasing the compression ratio, although this to a large degree depends on the shape of the combustion head and must, therefore, be a question of trial and error.

Advance Ignition Timing

A beneficial effect is usually obtained by advancing the ignition timing over that used on the petrol setting. To facilitate this, in view of most modern cars being fitted with automatic ignition advance, it helps to fit up a hand-controlled ignition advance. The conversion is not difficult, being a slight modification to the distributor-head bracket, and the usage of a push-pull control of normal design. By this means the ignition timing can be varied at will from the dashboard, and a lot of useful data can be obtained during initial tests.

Decrease Spark Gaps

It will be found that the spark-plug gaps can be materially decreased with advantage. As a matter of fact, on one particular test it was found that ·008-in. gaps on a coil-ignition 12-h.p. car gave very excellent results, as regards both maximum power and doing away with a tendency to pop back at lower throttle openings.

Tuning for Correct Mixture Strength

It will be found during tuning tests that variation in mixture strength does not seem to have as noticeable an effect with gas as it does with petrol fuel. Consequently, an exhaust-gas analysis tester saves a lot of time, and one of the well-known portable instruments, such as the Cambridge exhaust-gas tester, will show during running the CO_2 content in the ex-

haust gases. This should, of course, be kept as low as possible to obtain economical running.

Driving for Economy

While on the subject of economical running, it is as well to mention that a quite improved mileage can be obtained during a run by maintaining a fairly constant throttle opening and not " joggling " the accelerator pedal, as is often done normally on petrol vehicles. Also, due to the initial acceleration not being so good as on petrol fuel, it is only a fuel waster to open the throttle fully when starting off or going through the gears. Attention to these two points will save gas to no small extent.

Pressure of Gas

Reverting back to the subject of low-pressure gas bags, it is as well to remember that a small increment of pressure from that of the normal gas mains, i.e. 6-in. water gauge to, say, 3 lb. per square inch, does not result in a big increase in the volume of stored gas. Taking a fair-sized gas bag of 75 cu. ft. charged at 6-in. water gauge, this would increase in storage volume only approximately 20 per cent. when charged at 3 lb. per square inch pressure. This would mean only about another 15 cu. ft. being carried, which would mean, perhaps, another 1½ miles farther to run. So it will be appreciated why the storage pressure needs to be around the 3,000 lb. per square inch mark to give a reasonable range of operation.

Fitting the Mixer

In conclusion, the usual mixer is fitted on the induction manifold in place of the petrol carburettor, which is removed, but an alternative method could be used where the mixer is fitted to the air intake of the carburettor, thus leaving the latter *in situ* for emergency use. The butterfly throttle valve of the petrol carburettor would have to be held open, and also the metering piston in the case of an S.U. carburettor.

The fuel supply would have to be disconnected either by tap, or by removing the lead in the case of an electric pump.

These few details would not be a long job, and in any case would no doubt warrant being done by virtue of giving an alternative method of carburating the vehicle in the event of running out of gas or of mechanical trouble with the pressure valves, although the latter have been proved to be most trustworthy and efficient in service.

SYSTEMATIC BATTERY AND STARTER TESTING

By S. G. MUNDY, A.M.I.E.E., A.M.I.A.E., M.I.M.T.

IN making all electrical tests on the car it is necessary to carry out the work systematically, eliminating one possible fault after the other. This article describes an easy and systematic way of analysing the condition of the battery and starter.

1. Specific Gravity and Battery Inspection

Remove the battery vent plugs and measure the specific gravity of all cells, using a good syphon hydrometer. All cells should show similar readings.

A reading of 1·200 or less indicates that the battery is low in charge ; readings from 1·200 to 1·230 indicate a normal battery condition, and readings of 1·280 or over indicate that the battery is fully charged, or possibly being overcharged.

If the battery is old and has a low gravity reading, it may be approaching the end of its useful life, irrespective of charging rate ; this applies particularly under winter-driving conditions.

If the electrolyte is low, fill with distilled water to slightly above the level of the plates. When making a further specific-gravity test after the addition of distilled water, allow a short time to elapse for the water and acid to mix.

If it is found that there is rapid evaporation of the electrolyte, this may be due to overcharging—check the charging rate. If it is found that the electrolyte is low in one cell only, check for a cracked case or a partially short-circuited cell.

At the same time as the specific-gravity test is made, the battery should be carefully inspected. Use an inspection lamp if necessary. Carefully check the condition of the battery terminals and battery top for any evidence of electrolyte leaking around the posts or connections or through cracked sealing compound. Make certain that the battery is securely clamped in its carrier. If necessary, make a record of any unusual conditions found.

2. Battery Open-circuit Voltage

Connect a reliable moving-coil voltmeter across the battery terminals, or from a "live" battery terminal to "earth," and note the voltage reading.

For the complete battery the readings should be :

6-volt battery . . .	6 to 6·6 volts.
12-volt battery . . .	12 to 13·2 volts.

Readings of individual cells should be :

Not less than 2 to 2·2 volts per cell.

If the reading is at the rate of 1·8 and less than 2 volts per cell, it indicates that the battery is low and should be charged. A reading less than 1·8 volts per cell suggests that the battery probably needs repair or replacement.

3. Testing Battery Voltage under Starter Load

This is an important test, because it checks the condition of the battery and its ability to supply the current demand of the starter. The voltmeter connections are as for test No. 2, but it is convenient also to insert an ammeter between the starter and the battery. This can be done by removing the connection to the battery " live " terminal, connecting the cable to one ammeter terminal, and the remaining ammeter terminal to the " live "-battery post.

The starter switch should now be operated, and the voltage reading noted on the voltmeter. If an ammeter has been connected, also note the ammeter reading. The voltage reading of the complete battery should not be less than $4\frac{1}{2}/5$ volts for a 6-volt battery, and 9 to 10 volts for a 12-volt battery. If the reading is lower, or if it drops away rapidly, the battery should be removed for inspection.

The ammeter reading will show the current consumption. The value of current will depend upon the type, size, and voltage of the starter. It is not possible to give definite data of specific readings, as these vary according to circumstances, but data are available from manufacturers which will give an approximate indication. A more accurate check of the starter condition can, however, be obtained from a lock torque test, described later.

4. Checking Battery Cables and Connections

Troubles are frequently due to loose, dirty, or corroded connections or faulty battery cables. First, check for corroded or loose connections at the battery terminals, including the battery earth connection. At the same time check the cable which connects the engine to the chassis on rubber-mounted engines. Also inspect battery sealing compound, see that the ventilation holes in filler plugs are clear, that plug washers are fitted, and the top of the battery is dry.

The battery can be cleaned if necessary with soda or ammonia, " Vaseline " being applied to the connections, which, if required, should be re-marked for polarity with red and black anti-sulphuric enamel,

How to Check the Battery Cables and Connections

If required, the battery cables and connections can be checked with a voltmeter, as follows :

(*a*) Connect one voltmeter lead to the large starter terminal, and the other voltmeter lead to a cylinder-head nut. The voltage reading should be 6 volts or 12 volts or higher. With the starter operating, the minimum reading should be approximately 3·6 volts for a 6-volt system, or 7·2 volts for a 12-volt system. If the readings are above these figures and the battery terminals are clean and in good condition, no further check should be necessary. If, however, the voltmeter readings are below the above figures, a further check should be made, as follows :

A Check for High-resistance Connection

(*b*) Connect one voltmeter lead to the large starter terminal and the other voltmeter lead to the "live" battery post, i.e. the battery post which is *not* earthed. Operate the starter and check the voltage reading, which should not be less than 0·4 volt for a 6-volt system, or 0·2 volt for a 12-volt system. If the voltmeter reading is higher, this indicates that the starter-to-battery cable is too small, or that there is a high-resistance connection.

Checking the Battery Earthing Connection

(*c*) The battery earth connection often causes considerable trouble, and if the previous battery tests have not shown a satisfactory condition the earth cable should be checked, as follows :

Connect one voltmeter lead to the starter frame and the other voltmeter lead to the "live" battery post. Operate the starter with the engine in gear ; the voltage readings should be less than 0·4 volt for a 6-volt system, or 0·2 volt for a 12-volt system. If the readings are higher than these figures, check for corrosion or hard oxide coating on the lead surface of the battery terminals or connectors ; also check for rust or paint or a loose connection at the battery cable earthing terminal. The trouble is sometimes due to undersized battery earth replacement cables which may have been fitted, and if the trouble is elusive this point should be checked.

Is the Size of Earthing Cable Sufficient ?

Method of checking the size of the earthing cable is as follows :

(1) Connect one voltmeter lead to the battery post which is earthed, and the other voltmeter lead to the battery earth connector. Operate the starter, when the full ammeter reading should be less than 0·4 volts for a 6-volt system, or 0·2 volt for a 12-volt system.

(2) Move the voltmeter lead from the battery earth connection, and, using a prod, insert into the earth cable.

Repeat the above test with starter operating, when the voltage reading should be as above.

(3) Move the voltmeter test lead to the clamping bolt at the battery earth connection and repeat the test, when the readings should be as above.

(4) Finally, move the test lead to the car frame and again repeat the test. The same readings should be obtained.

The foregoing tests carried out systematically represent an exhaustive analysis of the condition of the battery on the car. Further tests may be required in the case of batteries removed, and these tests may, in the case of elusive troubles, include a cadmium test. Full information of cadmium testing is given in a subsequent article.

5. Testing Starter

The most satisfactory method of testing starters on the car is to carry out two standard tests, namely, a free cranking test and a lock torque test.

Before making either of these tests, however, remove the cover band of the starter, see that all the brushes are in good condition, that the spring tension is correct, commutator is clean and bright, and that there is no evidence of under- or over-lubrication, or any excess of copper dust or accumulation of dirt.

6. Starter Free Cranking Test

Connect one voltmeter test lead to the starter terminal and the other voltmeter lead to a cylinder-head nut. The voltage reading should be not less than 6 volts or 12 volts. With the gear lever in neutral and the ignition switch off, operate the starter. With normal specific gravity the readings should not be less than 4·5 volts for a 6-volt system, or 9 volts for a 12-volt system, providing the engine is warm, in good condition, and the oil is of the correct grade. The engine should turn at about 150 r.p.m.

7. Starter Lock Torque Test

This test is advisable if a further check of starter or battery is required. The gear lever should be in the top-gear position. Operate the starter momentarily with ignition switch off, and note the voltage with the starter turning. This should be not less than 3·5–4 volts for a 6-volt battery, or 7–8 volts for a 12-volt battery. The current consumption should be measured by connecting an ammeter in series between the starter and battery, as previously described, but if the voltage reading is below the above figures the cells should be individually checked. The voltage reading per cell should be not less than 1·2 volts, and all cells should be uniform. When the starter is released the voltage should rise to 2 volts per cell. Any lower readings indicate a defective or discharged

cell. An abnormal current demand, as indicated on the ammeter, indicates a defect in the starter, which should be removed for shop tests and service.

In making the lock torque test, see that each application of the starter is as short as possible, in order to conserve the battery charge.

The Importance of Battery Cables

Most service men are not usually familiar with the size of battery cables used with ordinary equipment, and there is the risk in service of using battery cables inadequate in current-carrying capacity.

It is most important that cable of the correct capacity should be used, in order to avoid a voltage drop, which will result in difficulty in starting the engine except under the most favourable conditions. If the cable used is too small, resistance is set up which impedes the flow of current to the starter motor.

This motor is a series-wound machine; its operation is governed by two conditions: (1) the amount of current, and (2) the voltage. The amount of current directly determines the torque or turning effort developed by the starter motor. The voltage directly determines the speed of the motor. It is, therefore, essential to deliver current of the maximum value and with the least possible loss in voltage in order to ensure rapid starting.

Another factor of under-capacity battery cable, with its resulting voltage drop, is also that the voltage at the time of starting will be low for ignition, because the primary ignition current is usually taken from a connection at the starting switch.

Poor connections will also promote difficult starting, particularly unsatisfactory earth connections. When trouble is experienced in starting, especially in cold weather, and all conditions which affect the problem have been treated, it is always as well to examine the starter cables. A check should be made for cable capacity, and should also include a check of the battery-to-starting-switch connection, battery-to-earth connection, starter-switch-to-starter connection, and the connection from the engine earth on rubber-mounted engines.

Why Battery Cables need Replacement

Battery cables are subject to occasional replacement, since there are several agents constantly striving to deteriorate the cable. The most active is acid. Acid will go from the battery during gassing whilst charging, by spilling, or may be carried out over the top of the battery by capillary action. It gets on to the battery post and battery terminal, on to the insulation and into the rubber, causing a corrosive effect which gradually eats away the terminal, the insulation, and even the rubber core. This possibility is protected against, by the manufacturer, by lead-

coating the battery terminals, terminal bolts and nuts, but this lead coating may become worn away.

Corrosion is visible upon inspection and may be minimised if frequent inspection is made, and any surface acid removed by washing the top of the battery with an alkaline solution. A suitable solution is water and baking soda, washing-soda, or ammonia. All corrosion should be scraped from the battery posts, connections should be made clean and tight, and a coating of "Vaseline" applied.

Another very troublesome symptom of corroded battery terminals is high voltage, the importance of which is dealt with elsewhere.

Correcting Defective Battery Connections

Many service men will cut the battery cable off short, strip the insulation a short distance, and fit a new terminal to a short cable. This is not good practice ; it shortens the length of the cable, which is probably none too long, and imposes a greater strain on the battery post. The result may be loosening of the post, causing much more damage than the cost of a new cable. Also, the job is often inconvenient, requires considerable time, and does not save any worth-while amount of money over the fitting of a new cable. It pays to put quality first and supply a new cable, giving the car owner a better job and earning a reasonable profit.

Another frequent cause of battery-cable deterioration is abrasion, caused by the insulation being rubbed through where it comes in contact with the frame. This causes a short-circuit, resulting in a run-down battery and possibly a great deal of damage to the electrical system of the car. It is not good practice to repair abrasion by wrapping the cable with tape. This is only temporary, and cannot last so long as the insulation on the original cable. It pays to fit a new cable.

One other cause of trouble sometimes experienced is terminals becoming loose from the core. This indicates that the terminals were not properly fixed in the original assembly. The condition is hard to detect, due to the fact that in outward appearance the cable looks O.K. It is, however, a point to check, and the best test is with a voltmeter.

SUCTION-OPERATED WINDSCREEN WIPERS

By JOHN L. P. PINKNEY, M.S.A.E.E.

THERE are three or four different makes of these windscreen wipers, all working on the same principle. They differ only in their size and shape.

Principle of Operation

A very similar method of working to that of a steam-engine is applied but, instead of pressure being employed to force the piston backward and forward, suction is used. This suction is obtained from the inlet manifold and, in some cases, from the suction side of the Autovac.

A slide-valve in synchronisation with the piston is also used, as in the case of the steam-engine, and its purpose is to direct the suction on to one side or the other of the piston, as required.

The valve slide is not solidly fixed in relation to the piston, but is made to operate quickly at the end of each stroke of the piston by means of a spiral spring on the break-back principle.

The reason for this action is easily understood as, without it, there would be a position of the piston which would place the port-holes in tha valve half open to both sides of the piston, and this would be liable to interfere with the proper working of the wiper.

Starting and Stopping Lever

A lever is fitted to enable the wiper to be started and stopped as required. Its action is to direct the suction to one of two paths. In the working position of this lever, a clear path for the suction is obtained through a channel cut in the metal casting of the wiper body. This channel leads to the centre hole of three. There is also a channel leading from each of the two outer holes to each side of the piston.

The Suction Path

Across these holes is the slide of the valve, and according to the position of the slide a clear suction path is made from the centre hole to either one of the outer holes. This allows the suction to move the piston in one direction and, at the end of the stroke, the valve slide is quickly moved over to change the suction path from the centre hole to the other

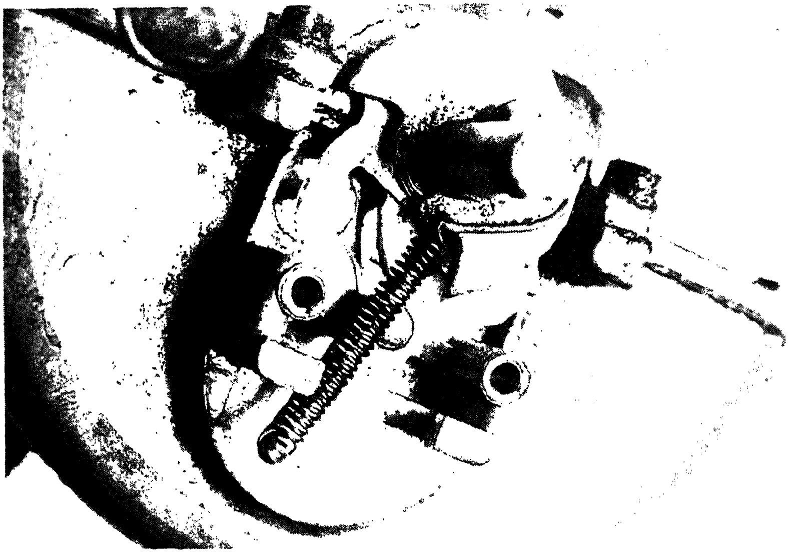


Fig. 1.—The valve mechanism of the Trico wiper

It is recommended that before removing the top of the wiper, the valve cover be removed and the mechanism closely inspected. It may be found that this mechanism may vary very much in different models of the same make.

outer hole. This causes the suction to move the piston in the other direction.

Parking the Wiper Blade

When the wiper is not required, the " on " and " off " lever is moved over, and this removes the suction from the valve channel and transfers it to one side of the piston direct. This sucks the piston towards the suction opening, and the rubber cushion fixed on the piston seals the opening. This automatically stops the wiper working and also moves the wiper blade into the parking position.

The Piston

The above description is of the Trico make, and the piston is a thick flat blade working in a semi-circle in a trough. The wiper spindle is attached to the top of this blade and, in action, this spindle receives an oscillating back and forth movement to the wiper squeegee blade across the windscreen. The other end of the spindle operates the slide-valve mechanism.

The Lucas Wiper

This wiper works on the same principle, but its shape differs from that of the Trico, being cylindrical. There are also two pistons inside the cylinder, coupled together by a connecting strip. This strip has two grooves cut away in its centre, and as the connecting strip moves back and forth these two grooves operate a cam which throws over the valve slide.

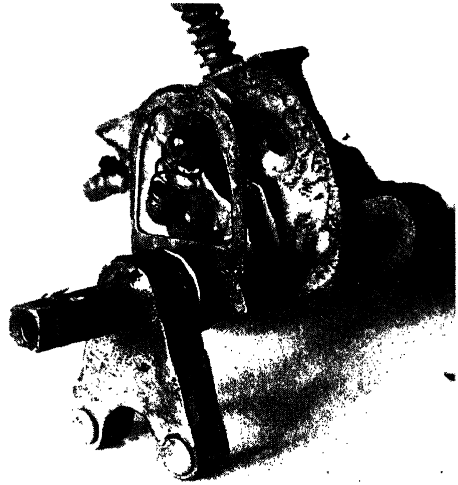


Fig. 2.—VALVE MECHANISM OF LUCAS WIPER

When the two halves of the cylinder of the "Lucas" wiper are separated, this valve mechanism may fall out. At the left of the valve gear is seen the cam referred to in the text.

Operating Pin

A spring-loaded pin is fitted to the outside of the wiper, for starting and stopping purposes. When the pin is pulled out and locked by giving it a half-turn, the pistons are free to move, but, with the pin released, its other end projects into the inside of the cylinder and presses on to the edge of the connecting strip. At the end of the piston stroke, the pin drops into a groove cut away in the connecting strip. This locks the pistons in position and stops any further movement.

Speed Regulator

To regulate the travelling speed of the squeegee blade across the windscreen, a regulating screw is fitted to the main suction inlet—or should it be outlet?—connection. If preferred, this screw can be used for starting and stopping the wiper.

Parking the Squeegee

As in the case of the Trico, the squeegee blade will automatically park itself when the operating pin is used, but when the regulating screw is applied it will be necessary to park the squeegee blade manually. This is provided for by a lever fixed on the end of the wiper spindle.

Fitting the Wiper

The fitting of suction-operated wipers is for all practical purposes the same as for the electrical-operated types, but to eliminate future troubles the following points should be observed.

CAR GREASING AND LUBRICATING EQUIPMENT

By J. ROSE

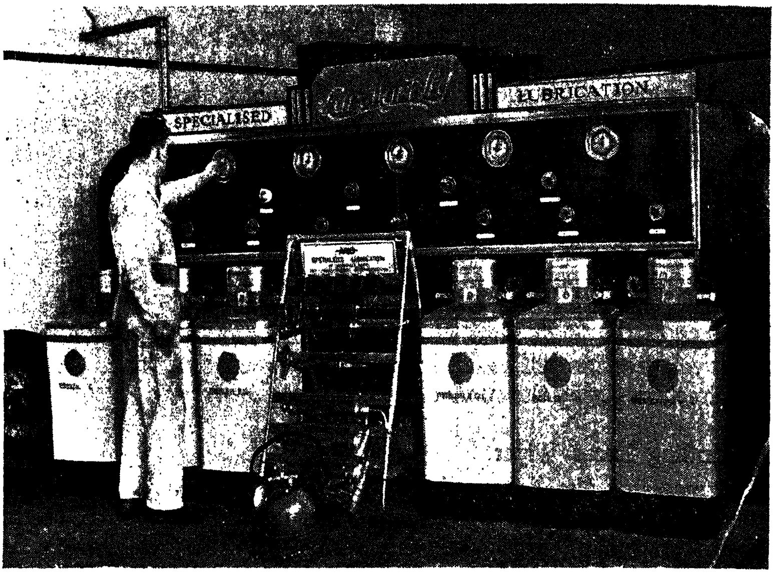


Fig. 1.—AN ILLUMINATED CAR GREASING AND CONTROL PANEL
(*By courtesy of The Car Mart Ltd.*)

OF all the different items connected with car maintenance, perhaps the most neglected until recent years has been the specialised lubrication department. At one time, greasing and the attendant operations were regarded as a " messy business," which must be carried out in some obscure corner of the workshop, but it is now becoming increasingly obvious that it is a most potential factor in the establishing of new contacts, and impressing customers as to the up-to-date efficiency of the service side.

It has, in fact, become the shop front of the service department, and as such merits close investigation. There are many firms to-day who specialise in the equipping of modern service stations with the most complete lubrication plants yet devised.

Fig. 2.—ON THE DRIVE-ON HOIST

The quick-filling unit being used to fill engine with flushing oil; at the same time chassis being greased with high-power, high-pressure greasing gun (400 lb. per sq. in. pressure). (*By courtesy of The Car Mart Ltd.*)

A Modern Lubrication Bay

Such a lubrication system has been installed by The Car Mart Ltd., who have fitted out their new service station at Hendon with every device calculated to deal with cars in the most speedy and efficient manner. Whilst there are undoubtedly many fine service stations situated in different parts of the country, let us examine this particular example of a modern lubrication bay, employing the A.R.O. system.

The lubrication bay itself covers an area of considerably over 2,000 sq. ft., and is situated at the front of the main building, allowing the public an uninterrupted view of all work being carried out. The psychological effect on business can be well imagined, particularly bearing in mind the ideal conditions under which the lubrication department is run.

Large sliding and folding glass-panelled doors at the front provide immediate ingress, and similar doors at the rear allow for access into the main shop, at the same time permitting the bay itself to be entirely closed off from the main workshop, in order that spring spraying, etc., may be carried out without any inconvenience to others.

Lighting

The walls of this bay are tiled to a height of 7 ft., enabling the whole area to be kept in spotless condition, and cleverly fitted concealed lighting

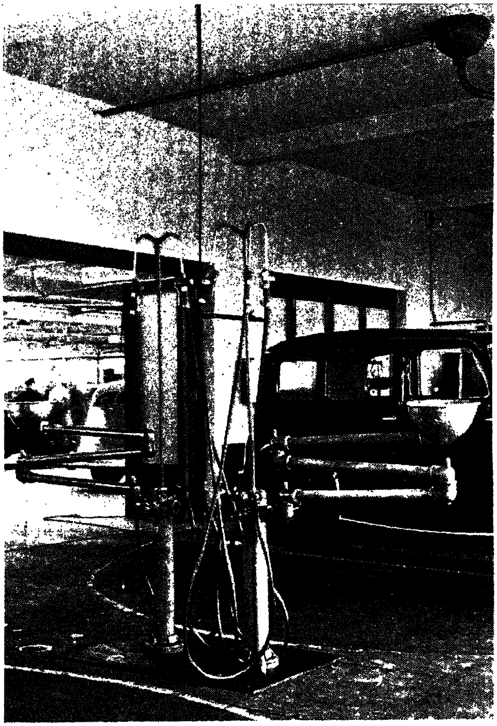


Fig. 3.—METERED GEAR OIL DISPENSATION WASTE OIL DRAINAGE UNITS

(*By courtesy of The Car Mart Ltd.*)

in the roof provides more than adequate illumination for night work, this light being diffused through opal glazing to provide an even distribution, at the same time preventing any view of the actual light-source from the outside. The whole atmosphere of the bay, both in daytime and at night, gives the feeling of spaciousness and cleanliness which is so essential to efficiency.

Drive-on Hoists

Occupying two-thirds of the floor area are two Globe drive-on hoists, capable of lifting 8,000 lb., considerable foresight having been displayed here in allowing sufficient space for the fitting of a further lift should this become necessary.

Owing to the difficulty of taking the hoist-control air-exhaust pipes outside the building, unusual ingenuity has been shown in the fitting of Burgess silencers to these pipes, in order to reduce the exhaust noise to a minimum.

These hoists employ the patented Globe principle, which, due to the design used, keeps all the oil below the piston, thus dispensing with the need for a packing gland, and eliminating the packing-gland pressure on the ram. This also permits the use of holes in the ram itself, and for the fitting of a safety bar which can also be used as a stop preventing rotation of the lift due to the special registers on the stop collar.

Oil Drains

Situated between these two hoists are specially designed universal swinging drain pans, by which all drainings are collected and discharged

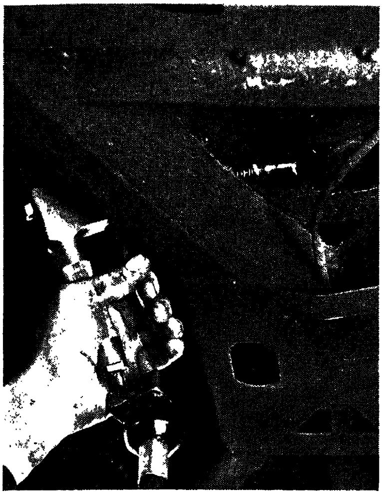


Fig. 4.—UNIVERSAL JOINT BEING GREASED WITH CASTROL HIGH-PRESSURE CHASSIS LUBRICATOR

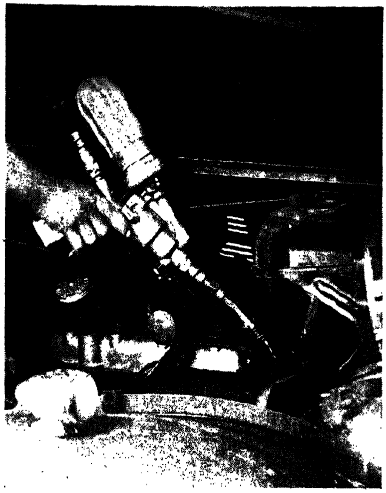


Fig. 5.—GREASING GUN AND WATER PUMP BEARINGS WITH AIR-OPERATED LUBRICATOR

Specialised lubricating oil is contained in the quickly detachable container.

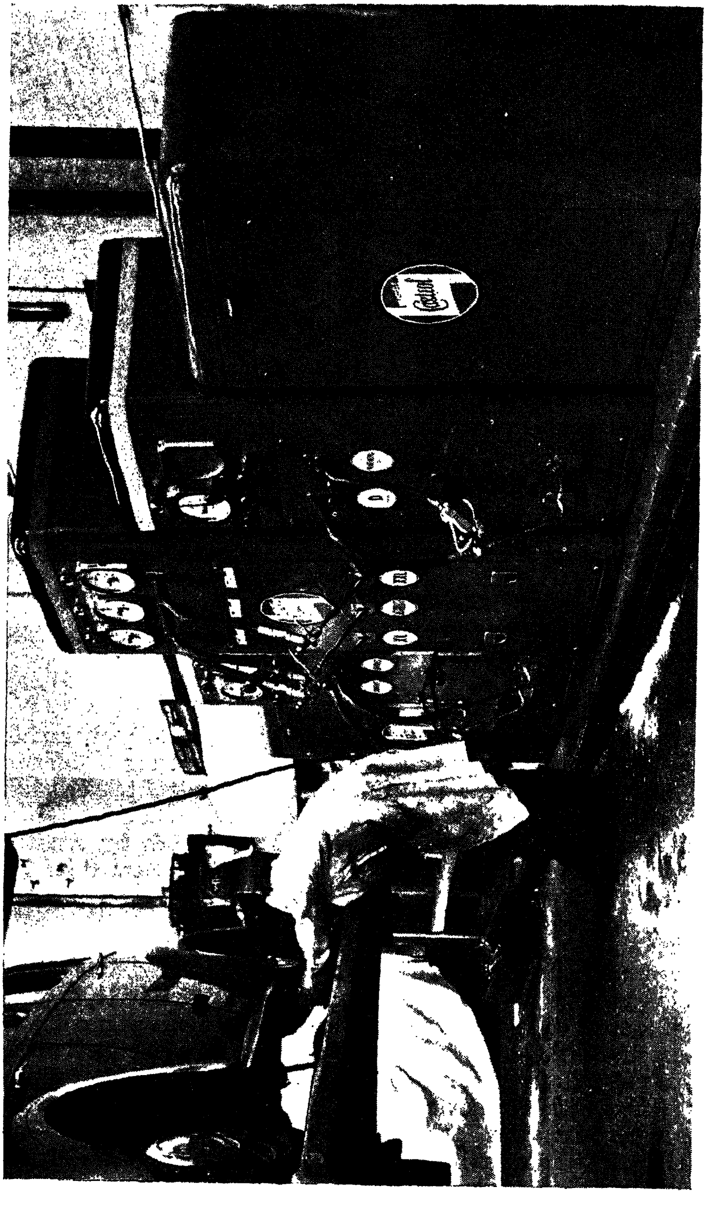
into underground storage tanks, the flushing from these tanks being effected by the application of compressed air.

Oil Supply

Adjacent to these drain pans is found a cluster of oil-supply nozzles with quick-action manual controls, each nozzle supplying a different grade of oil. These oils are piped through the control panel, where meters record the exact amounts dispensed to a fraction of a pint. All underground piping is made immediately accessible by centrally disposed cover plates in the floor, and all pipe lines are coloured for easy identification.

Grease Supply

The supply of grease is brought by means of overhead swing arms, one of each being fitted directly above the centre of either hoist, allowing any part of the car to be immediately accessible. Grease passes down a flexible hose from the swing arm to the actual gun, which incidentally is of a type suitable for grease-tight attachment to any kind of nipple. Running in line with the flexible grease hose is another hose suitably affixed at regular intervals. This carries air at 150 lb. per square inch pressure, the air pressure serving to operate the gun at one hundred or four hundred grease deliveries per minute as required.



6.—ANOTH TO-D CAT PLAN

pensers, th oil ch lubrica

Automatic Variation of Grease Pressure

If the part to be greased is free of restriction, lubrication at comparatively low pressure ensues; if, however, the part is rusty or the passage restricted in any way, then the grease pressure rapidly rises automatically until the passage is freed and lubricated.

Whilst not often encountered in everyday greasing, it is interesting to note that if necessary this type of gun can exert a pressure amounting to many tons per square inch. Although this high pressure can be developed, however, only 300 lb. grease pressure is the maximum in the hose on 150 lb. air pressure, the gun itself being responsible for building up the main pressure, thus resulting in very much longer hose life.

Fig. 7.—ANOTHER TYPE OF AIR-OPERATED LUBRICATOR—THE SENACON

The grease required is in the detachable container.

Air-pressure Line

Centrally disposed between the grease swing arms and fitted to the roof is the self-reeling air-pressure line, with a combined gauge and control affixed to the wall. Attached to this control unit are air connectors, so that air lines may be coupled up for the purpose of supplying the spring spray gun, this gun being of an advanced design in that adjustments allow for the concentration of the spray in such a manner that the amount of floating spray is reduced to a minimum.

Supplying Special Brands of Lubricants

Owing to the comparatively limited demand for certain special lubricants, but the importance of dispensing such lubricants when the occasion arises, the equipment includes a specialised lubrication rack:

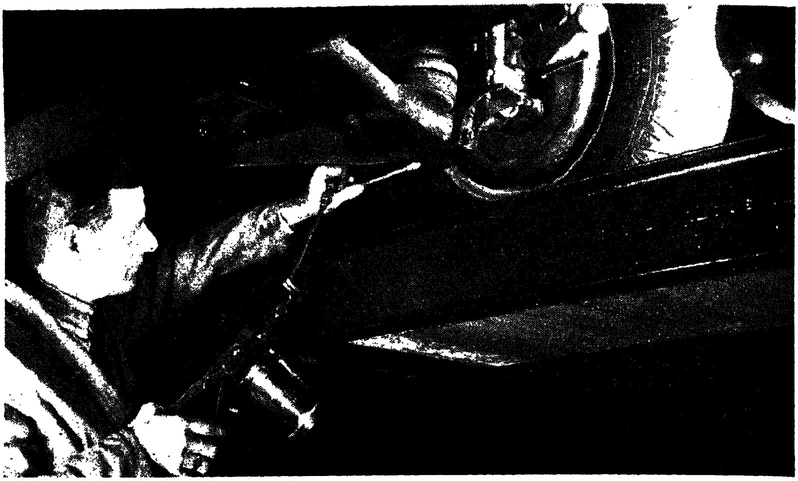


Fig. 8.—USING A HYDRAULIC LUBRICATOR

Showing the Jiffy grease gun. To operate, the handle is squeezed and the required pressure is given to the grease in the container by hydraulic action.

this rack incorporates a number of oil syringes and grease cylinders, and the air-operated portion of the grease gun previously referred to. These cylinders are constructed so as to allow of rapid attachment to the air-operated portion of the guns, and since each cylinder is filled with its own special brand of grease the entire system enables the correct lubricant to be dispensed to any part required.

Flushing Gearboxes and Rear Axles

Perhaps one of the most interesting accessories is the Visiflusher, which is used for the flushing of gearboxes and rear axles. This flusher consists of a pressed-steel spherical container, a venturi valve, tightly sealed glass bowl, and a service hose with a nozzle having a protective baffle. In use, the flusher is connected to the air supply, and held in the right hand, the venturi control valve serving as a handle. Pressing down on the control button creates a vacuum used to draw fluid into the spherical container through the hose, and with the control button down the thumb is placed over the venturi valve outlet, thus causing fluid in the spherical container to be expelled through the hose.

A small amount of flushing oil is used as a cutting medium to soften and dilute lubricants in the gearcase or axle, and this is alternately forced in and out of the unit in question until thoroughly mixed, after which the entire content is withdrawn by suction into the spherical container, and expelled into the waste oil drain.

The whole operation occupies but a few minutes, and the glass bowl permits the operator to observe the progress and thoroughness of the flushing.

The Control Panel

Probably the most impressive part of this equipment, however, at least from the customer's point of view, is the large illuminated control panel situated at one end of the bay ; of black enamel with chromium surround and surmounted by an artistic canopy, the inner confines of which provide indirect lighting for the whole, the panel serves, amongst other purposes, as a striking background for the equipment it is designed to control.

In front of the panel are six large cabinets, in which are contained specified lubricants for the more popular cars. Each cabinet incorporates a pneumatic force-pump which sucks the lubricant straight from the oil manufacturers' drums, and forces it direct to its appropriate nozzle in the cluster. On the panel itself are found the oil-registering meters previously referred to, and further attachments for air lines, the whole layout being designed to present a well-balanced appearance.

As will be realised, however, it is not possible to dispense each proprietary brand of oil in such a manner, and to overcome this difficulty compact steel shelves, with suitable racks, have been fitted out of sight behind the control panel, and stocked with practically every brand of oil which is in demand to-day. All oils so stocked are carried in dustproof glass bottles of varying capacities, suitably labelled, thus ensuring that all oil used is absolutely pure and free from foreign matter.

It is obviously unnecessary to comment on the value of such an imposing background for the lubrication bay, and whilst it may seem to some that the designers have perhaps been over-lavish in their attention to every detail, the consequent business has proved beyond doubt that the original outlay has been more than justified.

SPARKING PLUGS

By GEORGE T. CLARKE

Importance of Makers' Plug Markings

THERE is a tendency on the part of both owner and storekeeper to regard the sparking plug as a plug and no more. If he does not happen to have the one particularly suggested by the maker of the car or the plug manufacturer, he is very likely to fit a plug that looks like the one removed or a numbered plug nearest to the marking on the one at fault, or he fits a plug of a higher, or lower, number because he *thinks* the next number a superior type for the purpose. The real fact of the case is that he knows little or nothing about the duty of the sparking plug and what has led up to its design.

The Aim of the Plug Designer

In the early days of motoring the sparking plug was a poor affair. Its performance was by no means good although the requirements were so very little. It can be described as a piece of china with a length of wire through it. The only thing that was uniform was the thread, which was based on the plug used originally by Count de Dion. All designers of plugs attempt to attain the same end—to maintain the plug at the right temperature for the engine and at the same time keep clear of sooting up and carbonising on the surface of the centre portion of the plug.

The Multitude of Plug Designs is due to the Variety of Engines

Plugs are of so many designs to-day that it is proof that all engines, or nearly all, function in a different manner, necessitating many types of plug which, from an exterior point of view, cannot be distinguished one from another. The difference is highly technical, but an attempt will be made to give some idea as to the reason for this multitude of differences.

Plug Range compared with Engine Range

In an article of this length it is impossible to plumb the technical detail to its depth, but sufficient will be said to show the operator the importance of using his intelligence to the best of his ability if he wishes to obtain the best performance. As an example, if a graded range of engines from A to Z were fitted with 26 types of plugs numbered from 1 to 26 suitable for these engines, and were changed around so that plug

number 26 was fitted to letter-A engine, and plug number 1 was fitted to engine letter Z, it is very doubtful if either of the engines would run at all, let alone run satisfactorily. This is no exaggeration, but a real example of the trouble to which the plug maker has had to go to produce satisfactory running. One difficulty is that one person has designed the engine and another has had to design a plug to suit the former's product. The modern engine, with its very high compression ratio, has called for greater skill in plug design. It would not be so bad if one had to deal with a perfect engine, but there are no perfect engines, therefore the plug designer has had his hands full.

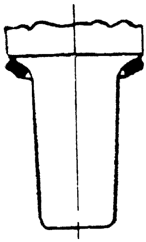


Fig. 1.—ORIGINAL CHAMPION PORCELAIN USED ON "COLD" LOW-COMPRESSION ENGINES

With increased engine compression, it is necessary to have a "hot" point and the insulator fairly cool. This is achieved by making the porcelain of the shape shown in Fig. 2.

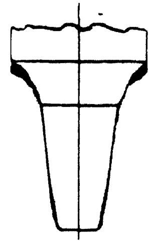


Fig. 2.—AS ENGINE COMPRESSIONS ROSE IT WAS NECESSARY TO HAVE A "HOT" POINT AND THE INSULATOR FAIRLY COOL

Therefore the porcelain was made smaller at the point, but uniformly increased in size to adequately radiate the heat not wanted within the

Heat-resistance of Plugs

Plugs have to be made within certain heat ranges and to deal with very sudden changes in temperature during which gas-tightness has to be maintained. Material that offers a high electrical resistance also offers a high resistance to the passage of heat, and herein lies one of the difficulties. The plug and engine designer desires controlled heat radiation, but has to deal with a material that must be of high electrical resistance.

Problem of Heat Transfer

The problem of heat transfer itself is now relatively simple, but there are other factors, such as over-oiling, that weigh against uncontrolled heat transfer. Many years ago, in the early days of the plug industry, it was customary to make plug insulators with practically straight lower ends, resulting in excessive heat at the firing-point. Fig. 1 portrays an early interior of a Champion plug. Experience has shown that it is necessary to provide a constantly increasing cross-sectional area through which the heat may travel and be absorbed, so as to eliminate the excess of heat at the firing-tip, or point. Practically all modern plugs have the firing-end of the insulator tapered to attain heat radiation.

Reason for Slow Heat Transfer

With a low-speed, low-compression engine there is little heat to absorb and remove. In this instance a long path is introduced in the

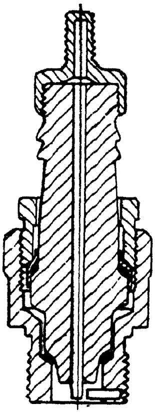


Fig. 3.—GOOD HEAT RADIATION BUT POOR CARBON RESISTANCE

This plug, on account of the copper gasket being near the thread, gives the shortest possible path for heat transference, but there is no "pocket" to give a large surface to the porcelain and so act as a resister to the formation of carbon and maintain the electrical value of the plug.

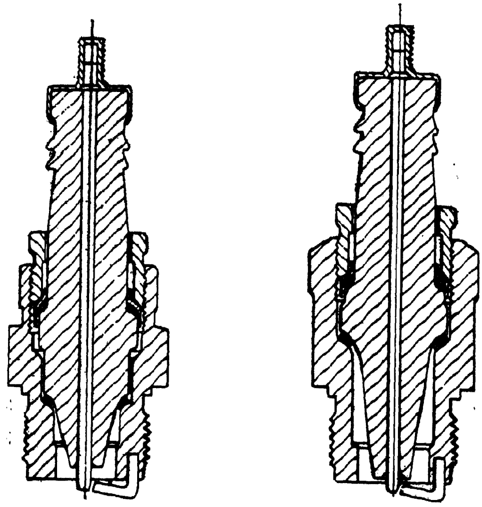


Fig. 3A.—HOT AND COLD PLUGS

Plug A shows a very short heat path and a longer surface to the inside porcelain. The plug is suitable for a very hot engine, but at the same time resists burnt oil. Plug B has a long heat path and a long oil-resisting surface and is not suitable for a very hot engine.

plug before the heat is absorbed by the surrounding engine casting and water jacket.

Difficulties under which the Plug Operates

The conditions under which the plug has to operate vary considerably even in the same engine. It may have periods of full load with an extreme temperature, which it has to withstand without the electrode overheating, and the insulating material must withstand the same heat without breaking down. The expansion and contraction must be such that it does not strain the sealing joint. The firing-end of the plug is exposed at the hottest point within the engine, and is subjected to great pressures and reactions, including chemical action. During all this the plug point has to overcome the erosion due to the passage of the high-tension current already surrounded by gases tending to erode the point itself.

Importance of Careful Selection of Plug

Not only will the selection of the right kind of plug for the job prolong the life of the plug, but the life will be more useful whilst it lasts. The

wrong kind of plug may function after a manner, but the average owner seems loth to change until the failure has become so apparent that he is forced to put his hand in his pocket.

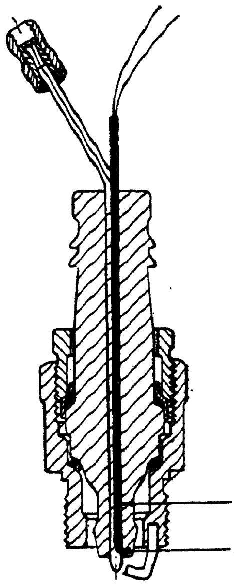


Fig. 4.—CHAMPION HEAT-RECORDING PLUG FOR EXPERIMENTAL PURPOSES ONLY

Rapid Failure of Incorrect Plug

The wrong plug fails internally very rapidly, often unknown to the non-technical driver. From full throttle the engine is continuously being shut down to an idling speed, when the plug cools off and is subjected to an over-rich mixture, which deposits soot and an excess of oil drawn past the piston rings and tends to carbonise on the surface of the insulator. Between these two extremes the plug has to function and maintain a clean and non-conductive surface on the interior face.

Ability to withstand Fracture at Critical Heats

If the plug is to give reasonable service it must, first of all, have a good insulator impervious to the absorption of moisture; the insulator must be a first-class electrical insulator during the whole of the engine range of heat, and it must be so situated as to radiate sufficient of the heat created to satisfy the conditions of the engine designer. The insulator must be able to withstand fracture at the highly critical heats. The electrode must be non-corrosive. Fig. 2 shows the principle of the tapered insulator designed and used by the Champion Company with the earlier type of plug (not even now obsolete). The larger area is clearly shown as the heat passes up the insulator.

Plug Construction for Very Rapid Heat Radiation but Poor Resistance to Carbon

In Fig. 3 is shown a plug with the gasket nearer the firing-end, so that the heat path is shortened as much as possible. The modern high-compression, high-speed engine needs to get rid of the heat generated on the plug point as rapidly as possible, hence the position of the gasket. The plug maker has to deal with many kinds of engines, and this is an example of what is called a "cold" plug for use in hot engines. Fig. 3A shows hot and cold plugs.

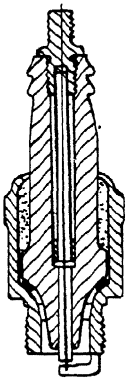


Fig. 5.—PLUG TO RESIST EXCESSIVE OILING-UP

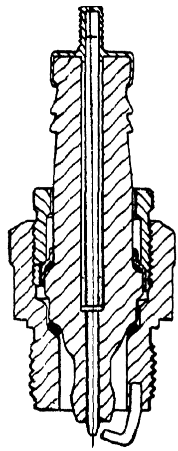
This has a larger space between insulator and plug body to resist oil fouling, but a little longer heat path. Somewhat of a compromise.

Endeavour to meet Engine Heat and Oil Resistance

As already mentioned, in plug designing it is necessary to provide different types of plugs which will, as nearly as possible, exactly meet the conditions of the particular engine in which they are to be used. The classification is called "heat range." In order to explore the requirements within the engine, "Champions" made up plugs with a thermo-couple within the plug (Fig. 4). It was found necessary to make such tests in order to make sure the plug recommended would reach such a temperature as was conducive to prevent pre-ignition, and yet reach a temperature high enough to eliminate the dangers of fouling the insulator.

Causes of Pre-ignition

It may be as well to note that pre-ignition in plugs is in practically all cases due to the overheating of the tip of the core to the point where it ignites the mixture in the combustion chamber before the spark takes place.



6.—PLUG TO PETROL FOULING

The neck restriction acts as a resistance to keep the larger portion of the porcelain at the end hot enough to keep it from fouling through "petrol," but oil fouling is governed by the length of the porcelain within the plug body.

Result of a Cracked Porcelain

A cracked porcelain, through being detached from the main body of the insulator, stores up heat until it incandesces and causes pre-ignition also. If very much detached it pre-ignites the gas to such an extent that a very high pitched knocking is heard which, to the unitiated, sounds as though a gudgeon pin had given out.

Causes of Fouling by Oil and the Result

Fouling of plugs is of two kinds—oil and petrol fouling. In the first case more oil than normal passes up by the pistons into the combustion chamber and is deposited on the insulator, and on the inner body of the plug. If this continues for any length of time the oil forms into a hardened cake and closes, or restricts, the space between the insulator and the plug body. The only remedy is to fit a plug with a larger space, somewhat like Fig. 5.

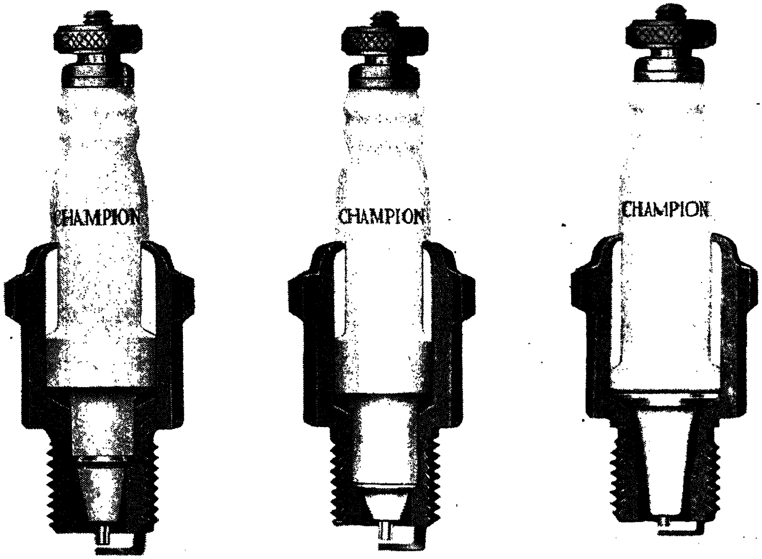


Fig. 5A.—Examples of Champion powder-filling gas-tight plugs

Causes of "Petrol" Fouling

Petrol fouling is different in character. When an engine is started cold, a blanket of carbonaceous material, or wet fuel, is deposited over the whole surface of the insulator, and forms, when the first heat is applied, into a dry, fluffy, carbon coating. As the heat increases the tendency is for this fluffy material to disappear from the insulator.

Real Reason for cleaning the Plugs after a Bad Start

This is one of the reasons that an engine, after a splutter or two, often requires the plugs cleaning. The fluff is a conductor, therefore with a deflated battery unable to create enough E.M.F. through the coil, the spark is conducted to earth via the fluff instead of jumping the gap.

Insulator Coldest at Gasket and the Trouble caused Thereby

Naturally the insulator is coldest at the point where it seats on the gasket, and there is a tendency for some of the condensed carbon to remain. As the firing-tip of the insulator is nearly reached. the temperature is high enough to remove the fluff which is deposited. As we get nearer still to the tip of the insulator the condition is a little different. With the very high temperature at this point, along with the tendency for a slight amount of oil to be mixed into the deposit at the tip, the

. 7.—PLUG CARBONED UP BEFORE CLEANING

Fig. 8.—PLUG AFTER CLEANING MACHINE SHOWN IN FIG. 9

mixture has an inclination to cake to some extent and perhaps bake into a hard crust.

Importance of Plug Temperature

As long as the temperature of the insulator midway between the tip and the gasket seat is maintained high enough to eliminate the fluff of carbon, the plug will not foul.

Design to maintain Tip Temperature

Fig. 6 shows a plug designed for this purpose. It is when the carbonaceous material from the tip meets the condensed material starting from the gasket seat that fouling actually takes place, and the current travels through this carbonaceous layer rather than jumps the gap. The problem becomes one of maintaining sufficient temperature at the immediate point to continue to eliminate the fluff and so prevent fouling. The insulator shown in Fig. 6 retards the flow of heat by reduction of area at the neck portion just long enough to retain sufficient heat to keep the core clean.

Limit of Temperature at Point of Plug

From the above it will be seen that to prevent petrol fouling in the ordinary plug it is essential to provide the necessary temperature at the intermediate point to prevent fouling, but the insulator can be lengthened only to an extent where the tip temperature will not exceed 1500° F. Petrol fouling can then be taken care of by increasing the length of the insulator, within reasonable limits, but in the case of oil fouling it is a question of added space within the plug.

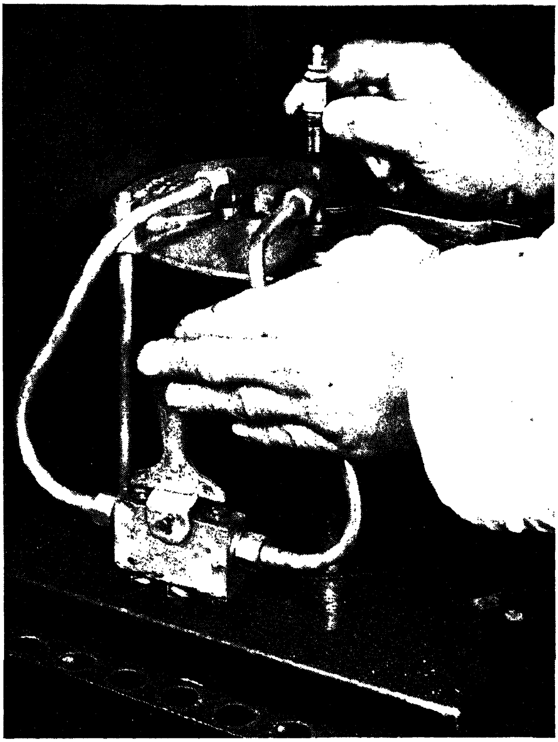


Fig. 9 (*right*).—PLUG BEING CLEANED BY SAND BLAST ON A.C. PLUG-CLEANING MACHINE

Why Smaller Plugs were Introduced

The first plug size used was the 18-mm., after which The Ford Company, mainly because the U.S.A. disliked anything bearing the name "metric," started the $\frac{1}{2}$-in. gas-thread plug. After that the U.S.A. introduced the $\frac{7}{8}$-in. × 18 thread plug. All three of these plugs are of ample size, and enable the plug maker very easily to combat the "heat range" business. But now we have a further three plugs, starting with 14-, and then 12-, and eventually 10-mm. diameter. The smaller plug commenced life with the small cylinder which, with a standard plug fitted, did not permit sufficient water space around

Fig. 10 (*right*).—BEING INSERTED IN TESTER OF CLEANING MACHINE

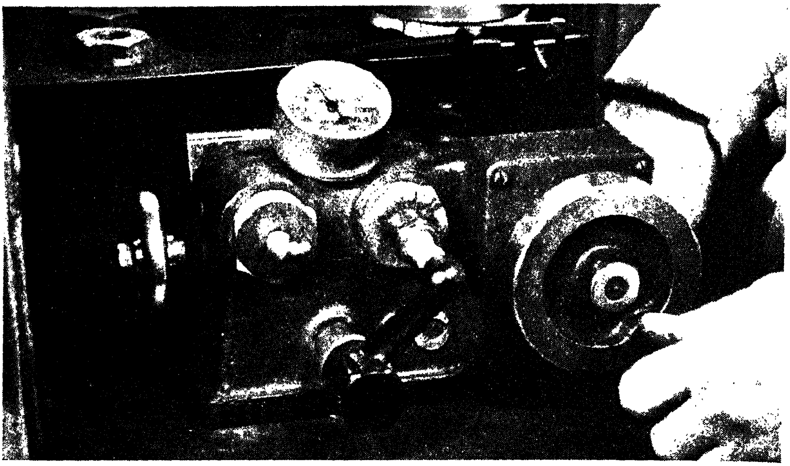


Fig. 11.—PLUG BEING TESTED UNDER PRESSURE

the top of the cylinder. It was therefore necessary to reduce the size of the plug and so reduce the diameter of the cast boss.

On the Packard Straight Eight and other engines with eight cylinders in line, it must be apparent how little space there would be for water with

PLUG DIMENSIONS

Nominal Diameter	*Outside Diameter*	*Pitch or T.P.I.*	*Double Depth of Thread*	*Root Diameter*	*Tapping Drill*	*Width Across Flats of Hexagon*
	·8750 in.	18	·0722 in.	·8028 in.	20·5 mm.	$\frac{1}{8}$
$\frac{1}{2}$ in. Gas	·8250 in.	14	·0928 in.	·7322 in.	47/64 in.	Various
18 mm.	·7087 in.	1·5 mm.	·0767 in.	·6320 in.	41/64 in.	1 in.
14 mm.	·5512 in.	1·25 mm.	·0639 in.	·4873 in.	12·5 mm.	
12 mm.	·4724 in.	1·25 mm.	·0639 in.	·3585 in.	"U"	$\frac{3}{4}$
10 mm.	·3937 in.	1·00 mm.	·0511 in.	·3426 in.	"S"	$\frac{11}{16}$ in.

a boss large enough to take an 18-mm. plug. Obviously, as we go to smaller plugs, instead of reaching standardisation in size suitable to all makes of engine, we have made the task of "heat control" in the plug more difficult.

Difficulties of Heat Governing with the Small Plug

Obviously, too, the conditions which have to do with fouling are made worse, and it is impossible to give more than a very small space to provide against all kinds of fouling. As we get into the smaller plugs we approach the cold types, in fact we get very close to the racing types

from the standpoint of heat path. The small plug reaches its normal temperature faster by some 10 to 15 seconds than the 18-mm. plug.

Gas-tightness of Plugs and its Importance

A very important factor of plug design and care in manufacture is the formation of the gas-tight seal. The reason this is so important is that a leak between the centre electrode and the centre insulator, or between insulator and shell, rapidly increases the temperature of the tip of the insulator and changes the normal rating of the plug. A leakage of 5 c.c. per minute, which is very small indeed, will increase the temperature at the tip of the insulator by approximately 35° F. The average difference between plugs next to each other in the heat range is approximately 40° F. The leak stated is equivalent to using the next hotter plug.

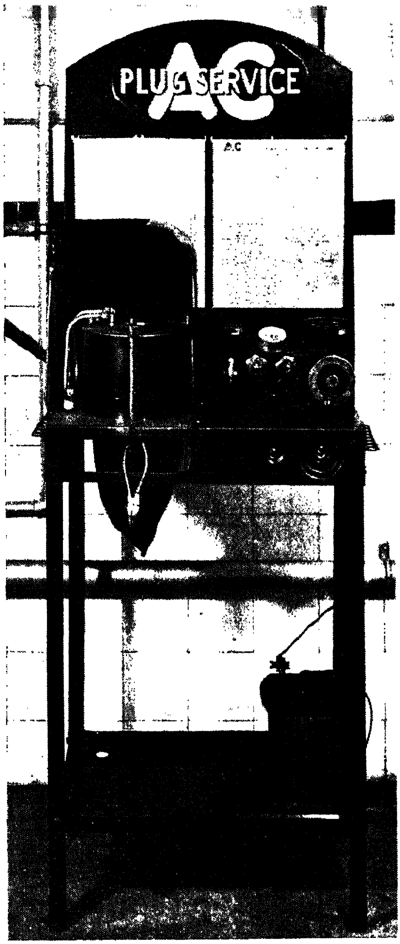


Fig. 12.—GENERAL VIEW OF THE A.C. PLUG TESTER

(*By courtesy of the Car Mart Ltd.*)

Leakage the Cause of Overheating

Leakage between the insulator and the shell must be of a higher rate than 5 c.c. per minute to cause definite overheating, but the danger is that of permitting the hot gases to reach the shoulder of the insulator, and cracking at this point. As is already known, the porcelain insulator of the Champion plug is made from "sillimanite," a natural non-metallic crystalline mineral formed ages ago from alumina and silica by the combined effect of pressures and temperatures of inconceivable magnitudes. The ore is mined and ground into a very fine powder, and a bonding material added, along with water, to form the actual material from which the "porcelain" will be formed under pressure. The porcelain is then glazed and baked.

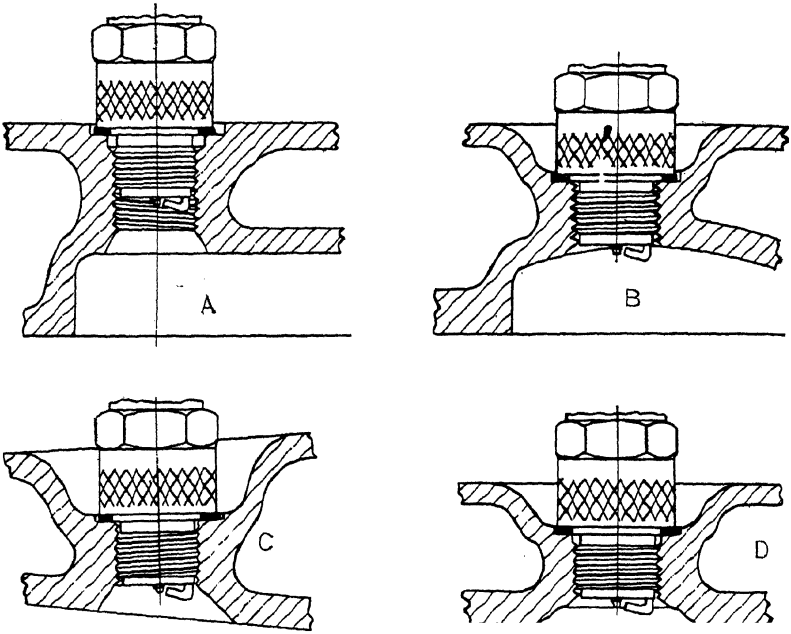


Fig. 13.—CORRECT AND INCORRECT THREAD LENGTHS
A—Incorrect fitting (thread too short). B, C, D—Correct fitting in various shaped heads.

In the earliest design of plugs it was customary to use a screw and nut to hold the centre electrode in place. Naturally this did not form a gas-tight joint, and, as the severity of engine conditions increased, plug makers found it necessary to provide a better seal, and some, for many years, have used a liquid cement of some kind which is baked to form a so-called solid joint. It is entirely natural that when a liquid is baked, the result is the expulsion of moisture and consequent porosity. It has been a problem to the plug maker. One of the difficulties has been to maintain sufficient tightness without making the column of cement so homogeneous that its expansion under great heat would not tend to split the insulator.

Powder Packing said to form a Good Gas-tight Joint

The Champion Company say they have entirely overcome the difficulty by tamping around the centre electrode a dry powder made from the same material as the insulator, and called "Sillment." This means that the plug cannot be taken to pieces for cleaning, but the modern plug-cleaning machine makes dismantling unnecessary.

Dismantling not now necessary to clean Plugs

As a matter of fact many plugs failed after dismantling because they were not re-assembled correctly, perhaps because the operator had no new gaskets and depended on the old one.

Disturbed Copper Gasket the Cause of Subsequent Trouble

In any case the copper gasket plays such an important part in the heat range of the plug that it is as well it cannot be disturbed from the position in which it has been placed by the expert. The one-piece plug has simply a flange turned over against the packing at the upper shoulder of the core. The dry-powder construction is resilient, and can come and go with the contraction and expansion of both shell and insulator, and so remains tight no matter how hot the plug may be run. With tightness ensured one is certain of the equal performance of the set of plugs installed.

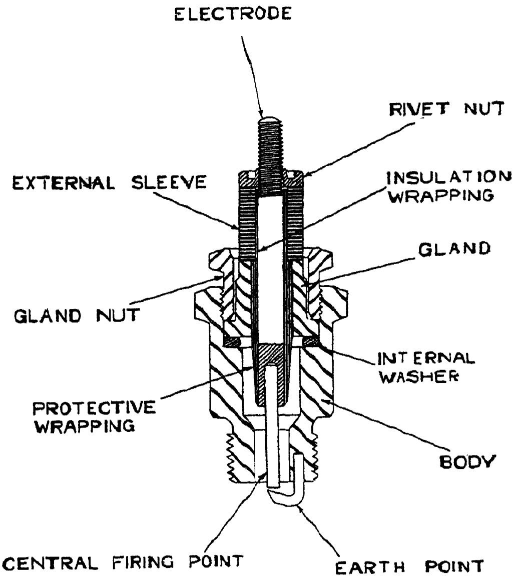


Fig. 14.—VARIOUS POINTS IN K.L.G. PLUG MANUFACTURE

The example shown is the K.L.G. type G.1 plug. The central electrode is well protected with wrapped mica. Note the long heat path for a cold engine and the large pocket as a restrictor to oiling up.

Position of Plug Gap within the Cylinder

Another important factor is the position of the plug gap within the combustion chamber. All plugs are made in different lengths of the threaded portion, so that the gap should be at the desired point of ignition. The modern engine is very much more particular as to the sparking position, and the projection into the head of the threaded portion of the plug may lead to overheating of the sharp points and lead to pre-ignition. This point needs to be watched very closely, especially with the smaller 14-mm. plugs, where the original standard 14-mm. is $\frac{3}{8}$-in. thread in length from gasket seat to the end of the shell.

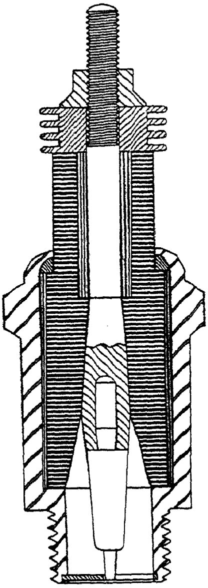


Fig. 15.—THE K.L.G. PLUG

This shows the design of the first sparking plug as developed by K. Lee Guiness.

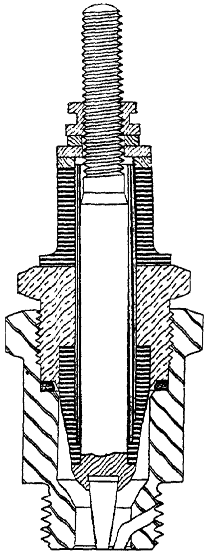


Fig. 16.—K.L.G. TYPE F.12

Gas-tightness produced by swaging the gland nut around the wrapped mica. Inner wrapping of mica ground and polished as a resistance to heat. This plug is suitable for the average engine without very high compression ratio or excessive heat.

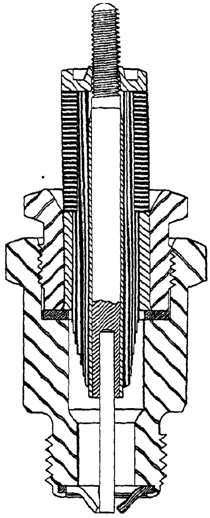


Fig. 17.—K.L.G. K.1

Note stepped wrapping to resist oil corrosion and large "pocket" for the same purpose. The enlarged copper-covered electrode has increased heat conductivity.

Plugs in Aluminium Cylinder Heads

In many instances aluminium heads are used for high compression, and it has been found necessary to go, perhaps, to $\frac{1}{2}$-in. and in a few cases to $\frac{3}{4}$-in. thread length. This again multiplies the number of types required, because in each particular instance the thread length is meant to meet the requirements of a particular engine. (*See* Fig. 13.)

Importance of correctly tightening Plug in Cylinder

A word or two as to tightening the plug in the engine. It is not easy to bring home to the average motorist the difference between 35 and 40 ft./lb., but the garage mechanic is in a different position, therefore

he should fully appreciate the following. If a 14-mm. plug is installed with a 30-ft./lb. torque, it will get too hot because there is insufficient heat transfer between the shell of the plug and the plug washer. If, on the other hand, it is pulled up to 45 ft./lb., it is apt to leak between the insulator and the shell on account of excessive strain.

Mica Plugs

To illustrate our remarks, we have used the Champion plug with its porcelain insulator as an example. The K.L.G. plug makers, however, use mica in their plugs as well as a form of porcelain. The mica-insulated plug will be explained on account of its approach to the same goal from an opposite angle. The plug was evolved by Mr. K. Lee Guiness when he was a racing motorist. He had trouble in finding the right plug for his racing Sunbeam car, and this led him to set up an experimental shop, and in that shop he carried out a vast number of experiments with many classes of material. Fig. 15 shows the result of his activities. The motor owner has reason to be grateful for his patience.

Mica Washers are not the Real Insulators

The average operator, or garage mechanic, often thinks the insulation of this plug depends upon the mica, as seen in the external sleeve of the K.L.G. plug portrayed in Fig. 14. The external sleeve is the mechanical protection of the plug proper, whilst the actual insulating mica is wrapped around the centre electrode, and termed "protective wrapping" in the same illustration. In describing this particular make of sparking plug the nomenclature will be as Fig. 14. This natural mica is very finely laminated, and the sheets may be split readily into many thin sheets of one- or two-thousandths of an inch in thickness, almost similar to cigarette papers. The very thin sheets are quite flexible, and they are known as "wrapping mica." Other sheets are split into thicknesses of about $\frac{1}{32}$ in. and are subsequently punched to form washers of about $\frac{3}{4}$ in. diameter, with a hole in the centre to suit the design for which they are to be used. As said, the washers only serve the purpose of protecting the wrapping mica from heat and damage, also, in some cases, providing a gas-tight wall.

Value of Mica as Sparking-plug Material

The mica for a sparking plug has to meet three primary requirements, the first being adequate electrical insulation for the centre electrode; secondly, a protective covering must be provided for the part of the electrical insulation which is exposed to the gases in the cylinder; and, thirdly, the complete assembly of insulation and central electrode must provide a gas-tight joint in itself.

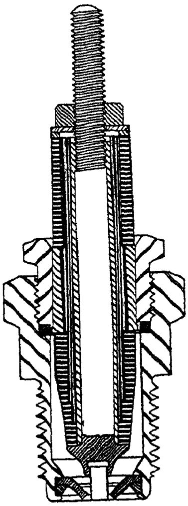


Fig. 18.—K.L.G. type V.7

Non-corrosive electrode for very high temperatures, copper plated to maintain heat conductivity. The gas-tightness is obtained by a special wrapping (not wrapped mica) so that the joint is effected without strain on the wrapping. The result is a higher factor of safety.

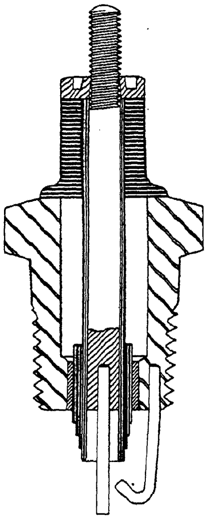


Fig. 19.—K.L.G. type Ford

Note the protected electrode surface from splashed oil and heat conservation of the centre electrode. The thin wire points are to stop heat radiation as much as possible.

This plug was produced for the old Ford model T.

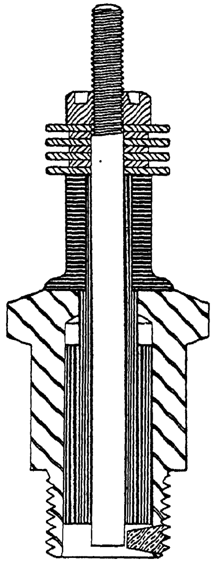


Fig. 20.—K.L.G. type 317

Plug for very high temperatures such as exist in two-stroke engines that have no over-oiling trouble. Note small electrode insulator surface, only permissible when oiling is non-existent.

Wrapped Mica as the Electrical Insulator

The insulation mica may be wrapped either directly on to the central electrode, as in Fig. 14, or on to the inside diameter of the body, as in Fig. 15. The protective covering may consist of mica washers or a further wrapping of "wrapping mica," fitted over the insulation wrapping, as in the case of Fig. 14, and inside it as in the case of Fig. 15.

Gas-tightness of Plug with Mica Insulation—Early Methods

The gas-tightness is obtained either by compressing longitudinally the mica washers which form the protective covering, a method which is almost obsolete, or by turning over the edge of the plug body. In the

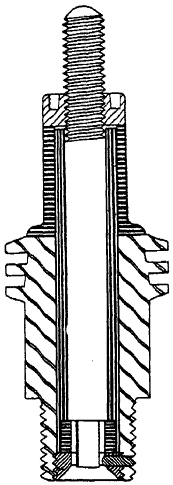


Fig. 21.—K.L.G. TYPE 646

Racing type plug of very high heat conductivity, but little surface against oiling. The life of the plug is short but more than long enough for the purpose for which it is designed.

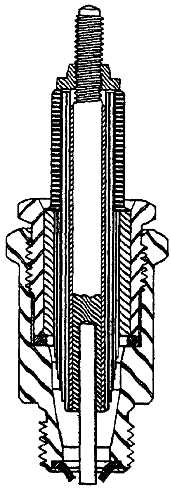


Fig. 22.—K.L.G. LK.1

Note oil baffles forming the earth side of the plug, the stepped mica, and large "pocket" as a protection against fouling. The plug is suitable for a semi-cold engine.

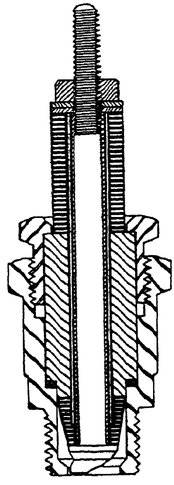


Fig. 23.—K.L.G. TYPE 718

Note the short heat path to conduct the heat from a "hot" engine and the shaped electrode to assist heat radiation.

case of detachable plugs the gland which surrounds the central electrode, or insulator, is screwed down to compress the mica to form a gas-tight joint. Apart from these primary methods of construction, the makers have to provide for the requirements of the actual engine in which the plug is to be used. To use the words of an authority of the K.L.G. Company: "In this, the specification of the engine as regards the position of the valves, compression ratio, maximum speed, and type of cooling will provide considerable guidance, but it would be a very bold plug designer who would undertake to produce the correct plug without a certain amount of trial and error under actual working conditions."

Importance of Valve Disposition to Plug Performance

As an example of the "heat range," etc., it will be as well to deal with two plugs, one of the "wrapped" type and one of the "washer" type (Figs. 14 and 16 respectively). Both these plugs have met with a large measure of success, each in its own sphere. To-day both of these plugs have been superseded by later developments, but they are excellent

examples of the treatment of the mica. In Fig. 14 we have a central electrode of mild steel, with a firing-point of nickel inserted into its lower end. This electrode carries two wrappers of mica—one of which is the insulating wrapping extending to the top of the outer sleeve, and a second, which is the protective wrapping only to the top of the gland. These wrappings are, in the first place, wrapped as closely as possible on to the electrode and finally gripped by contraction of the gland.

Method of producing Gas-tightness with Mica

This contraction is effected by a swaging process, and is continued until the mica between the gland and the electrode is so far compressed as to prevent any leakage of gas through it. After the gland has been contracted and a gas-tight joint obtained, an external sleeve composed of mica washers is threaded over the external end of the insulating wrapping and retained in place and under compression by means of a rivet nut. It will be clear that this external sleeve serves, not only to protect the external part of the wrapping from accidental damage, but also to form a finish to the plug.

Polishing the Mica for Resistance to Heat

The inner part of the protective wrapping is ground to a taper and polished so as to form a protection that has, in itself, the greatest resistance to the action of the heat and a reasonable resistance to the deposit of carbon and oil. This insulated and protected centre is then mounted in the plug body and retained in place by the gland nut, so that its inner insulation lies in the gas chamber and its central firing-point extends through the mouth of the plug until it is only separated from the earth point by the width of the gap. The construction is one that may be called suitable for the ordinary engine, provided the dimensions of the various components are suitably chosen.

Importance of "Pocket" and Inner Insulation to Varying Conditions

The possible variations are the length and diameter of the inner insulation, the depth and diameter of the gas chamber, the length of the central firing-point, and the diameter of the mouth of the plug. It is apparent that there are many combinations of these variations, but speaking broadly the larger the diameter and the shorter the length of the inner insulation the greater will be the heat resistance.

Area of Surface Insulation an Important Factor

In addition, the heat resistance of the plug may be raised by decreasing the volume of the gas chamber. There is a limit to the advantage which can be taken of these possibilities, as, if the inner insulation is shortened

too far, its surface will become too short to be effective, whilst if the volume of the gas chamber is reduced too far it will readily become choked. The K.L.G. plug shown in Fig. 16 is far more complicated. In this design we start with an electrode made from high-tensile steel which has an enlarged head formed at one end integral with the stem. This head is recessed and a firing-point of nickel is caulked into it. The insulation wrapping of mica is formed into a tube by wrapping on a mandrel, which is withdrawn when the tube is inserted into the gland. Whilst the tube is held by the gland the protective mica washers are slipped on its inner end and the external sleeve washers are put on its outer end. The electrode is then passed through the tube from its inner end, so that the underside of the head seats on the end of the assembly of protective washers, while the nut on the outer end of the electrode screws down on the top of the external sleeve.

Gas-tightness dependent on Gland Nut

It will be seen that the inner protective washers and the external sleeve are compressed longitudinally by the tightening of the nut, and the gas-tightness of the plug depends on this tightening, a tightening which must be carefully regulated to make certain that only sufficient pressure is applied.

Result of Excessive Pressure on Gland Nut

Excess of pressure will entail damage to the washers when the mica expands under the heat of working conditions. In this design we have a case where the external sleeve of washers is more than an ornament, as it actually serves as a distance-piece. Fig. 16 may be considered typical of the washer form of plug construction.

Fig. 17 is a plug still having the general form starting with a straight central electrode and bearing a wrapping of mica, but the electrode is made from a special form of material having a core of steel and a casing of copper closely welded to the core.

Heat Conductivity through Copper-covered Electrode

The steel core provides the strength and the copper provides increased heat conductivity. The increased conductivity reduces local heating, and considerably increases the heat resistance of the plug as a whole.

Stepped Wrapping to increase Resistance to Oiling-up

In Fig. 14 the protective wrapping is finished off to a taper, whilst in Fig. 17 the inner wrapping is finished off in steps. The step formation is not so resistant to heat, but the design is possible on account of the lower temperature of the electrode in that full advantage can be taken of its peculiar resistance to deposit. In addition to the improved heat

conductivity of the electrode, the gland is no longer isolated. With the plug in Fig. 17 the gland is of tubular form, and after contraction is turned on its outside diameter and firmly pressed into the gland nut, so that heat is not retained in it but can flow readily to the body of the plug. These two improvements in heat conductivity compensate for the loss of heat resistance of the stepped wrapping, and permit a design of added resistance to the formation of carbon deposit.

Heat-resisting Electrode for High-compression Engines and Large Pocket for Excessive Oiling

The plug shown in Fig. 18, although the general arrangement appears to be very much the same, has an electrode made from a non-scaling steel (something like exhaust-valve steel) which also retains its strength at high temperatures. It is smaller in diameter, but its heat conductivity is increased by a copper tube pressed on to it. An inserted firing-point of nickel alloy is retained, as in Fig. 17. The main difference, however, is that this design no longer depends on the longitudinal compression of the protective washers to provide a gas seal, as in Fig. 16. Instead, a gland of steel in tubular form is used, and this is contracted on to the insulation wrapping, which is reinforced, under the tube, so that a gas-tight joint is secured at this point quite independent of the protective washers. This results in a much higher factor of safety for the plug as a whole, and avoids the risk of the washers being compressed to a dangerous point in the effort by the inexperienced to make the centre gas-tight.

Plug designed for the Special Conditions of the Model T Ford

The foregoing practically covers the methods adopted by the K.L.G. Company to produce a plug to cover both the " heat range " and the resistance to corrosion, but Fig. 19 gives some idea of the extremes to which plug makers are forced to go to produce the correct plug for certain engines. The Ford plug (Fig. 19) was produced to meet the requirements of the old Model T, in which the gas temperature was abnormally low (the compression ratio was only 3·6 to 1), while the supply of oil in the combustion chamber was liberal. The difficulty was to provide an insulator which would be heated sufficiently by the low gas temperature to enable it to defend itself against the oil. With this object in view, the mica wrapping was allowed to extend beyond the end of the electrode and the gas chamber was entirely eliminated, so that the wrapping extended right into the combustion chamber in the form of a skirt which would collect all the available heat. The actual firing-points were made of small-diameter wire, and the external surface of the mica was stepped in order to increase still further its resistance to oil, whilst the spark gap was formed to give the least chance of being bridged with liquid oil. The Model T has almost gone, but it afforded an excellent example of plug design.

Two-stroke Plug designed for High-temperature Engines with no Oiling Trouble

The extreme in the opposite direction is shown in Fig. 20. It was designed for a two-stroke engine in which the gas heat was very high although the trouble from over-lubrication did not exist. The electrode was of copper with the largest amount of wrapping possible. The large bundle of wrapping was inserted in the plug, and then the whole body was swaged down to compress it into a solid gas-tight mass. After compression the inner end of the wrapping was turned off flush just above the bottom of the plug, and the earth wire was inserted to make the gap. This resulted in a surface of " end-grain " compressed mica and, although the leakage path was very short, it proved to be long enough in a clean engine.

The Right Plug for the Engine is more than an Ordinary Precaution

There are any number of designs of plugs on the market, but it is advisable to use those with talented research behind them. It never was a case of " any old plug will do," even with the original low-compression engine, but the modern engine requires a plug of first-class finish and with first-class brains behind it. We have not yet got to finality in plug design, exactly as we have not yet got to finality in engine design. Until then it is a case of experimentation, and only those with well-equipped experimental departments are likely to meet requirements. In any case it is as well to remember that the best of plugs wear out; therefore there comes a time when the plug can no longer be of any economic use.

Large Spark Gaps under Certain Circumstances

There seems to be a great deal of misunderstanding about wide gaps in the region of ·040 in. to ·060 in. As a matter of fact, the wide gap is a feature of the Vauxhall Ten, and in this engine it has undoubtedly contributed to low petrol consumption, but this low consumption is attained by carburettor setting and a system of gas distribution that provides each cylinder with such a uniformity of weak mixture that performance is enhanced. The shape of the combustion chamber has much to do with the results obtained. From this it is obvious that the mere widening of the gaps in any engine which has not been designed and adjusted for an abnormally weak mixture will have no effect and only lead to some form of ignition trouble. With normal running (not racing) the Lucas and other first-class coils will stand up to the work, but the outside insulation of the plug, if dirty or too short, may permit the current to flash over the terminal to the body of the plug, and more especially in damp weather on starting first thing in the morning. The fact, however, must be faced that the whole of the ignition will be more highly stressed by experimenting with wider gaps, and the result, unless the engine is designed for the change, is not worth the trouble plus the likelihood of ignition failure.

TESTING IGNITION COILS AND CONDENSERS

By S. G. MUNDY, M.I.E.E., A.M.I.A.E., M.I.M.T.

COIL TESTING

THERE is a considerable variety of apparatus offered for testing ignition coils. Most of these testing devices depend upon a visual test of the length of the spark as a measurement of the efficiency of the ignition coil. To test ignition coils merely by spark length is not, in itself, a sufficiently accurate indication of the ability of the coil to function satisfactorily on the engine.

Conditions which Affect Length of Spark

There are a very large number of conditions which affect the length of spark and which make it difficult to establish a standard.

To analyse the problem, we should consider what leads up to the creation of a spark across the sparking-plug gap. When the contact-breaker points are closed, current flows in the ignition-coil primary circuit. When these contacts separate, the ignition coil begins to build up voltage in the coil secondary winding at a very rapid rate, something in the order of 50,000,000 volts per second. This voltage rise, however, continues only for a very short period, and until sufficient voltage is induced to cause a spark to jump the sparking-plug gap. There are many conditions which affect the voltage required to produce this spark, such as the temperature, the nature of the gases around the sparking-plug gap, etc.

If, for example, 5,000 volts are required to produce a spark under the conditions which exist in the cylinder, the period of voltage rise would be only $\frac{1}{10000}$ sec. Under this condition there is no need for a higher voltage, and if the time interval or the period during which the contact-breaker points were open is longer, it means that the current will flow across the sparking-plug gap for a longer period.

In practice, the design may require a spark of a given voltage but longer duration ; such coils have a fewer number of secondary turns. On the other hand, the design may call for a coil with more than the usual number of secondary turns to give a higher voltage of shorter duration.

It will be realised from these considerations that the design of an ignition coil is, in practice, highly complex. We have to consider the conditions which control the voltage which the coil can deliver to the sparking plugs, including the primary current, number of secondary turns, the primary inductance, the resistance of the secondary circuit, and its electro-static condition.

Can Coil Make Up for Losses Caused by Faulty Plug?

Another factor which must also be considered is the sparking plug itself. The insulating resistance of a sparking plug has an important effect upon the length of spark which the ignition coil is able to produce. This resistance is the extent to which an electrical leakage can be prevented across the porcelains or through the deposits which form on the porcelain.

It will be appreciated that satisfactory results in ignition-coil testing, and particularly ignition-coil replacements, cannot be carried out in a haphazard way. We must be satisfied firstly that our methods of testing are correct, and secondly that all replacement coils we may fit are of the most suitable design for the characteristics of the engine.

The ideal ignition coil is one which is capable of producing a length of spark across the plug gaps to deal with all normal operating conditions, but to have a reserve to make up for any loss occasioned by a leaky plug.

A coil which has a very long spark length, as measured on the spark-gap test, may have quite a low secondary current, and in consequence not the same reserve as with a coil which has a relatively low number of secondary turns.

These various considerations show that theoretically correct and complete methods of coil testing are extremely difficult to provide. To carry out coil testing properly and to predict the performance of the coil under operating conditions it is necessary to get a very accurate indication of the characteristics of the secondary current. This means that an oscillograph should be used, which will show a picture of the peak value of each secondary-current impulse and its duration. This class of equipment is not practical for normal service; it comes in the category of laboratory instruments.

Comparing Coil under Test with Master Coil

For general service work a suitable alternative is to test a coil by comparison with another coil of the same make and type, and to use testing equipment which indicates not only the length of spark but also measures the current consumption of the coil. It is a fallacy to judge an ignition coil entirely by the length of spark it produces. If this test is coupled with a measurement of the current consumption, and a check is taken to see that this current consumption is normal, and the coil being tested is compared with another coil of the same make and type,

it should be possible to deal with ignition-coil troubles with practical satisfaction.

One other very important factor always to remember is that merely changing the coil will not remedy all ignition troubles of modern high-speed, high-compression engines. Every other possible trouble must be carefully tested and eliminated.

Coil Replacements

When dealing with coil replacements a lot of uncertainty exists. There are many replacement coils offered to the trade with all sorts of claims to superiority and ability to correct various kinds of ignition troubles. Such coils are advertised as superior coils and high-speed coils. Care should, however, always be taken in deciding whether to use one of this type in preference to the standard type as fitted to the car by the manufacturer.

The selection of an ignition coil, as we have already seen, is not a haphazard job. The coil characteristics are carefully considered by the car manufacturer, and he selects a coil which is capable of suiting the characteristics of the engine to which it is fitted. It is for this reason we suggest that the wisest course is the use of a replacement coil of the same make and type as originally fitted to the car.

Such manufacturers do not always consider the entire ignition system in the design of their coils. It must be appreciated that the ignition coil is only one part of the complete ignition system, and the aim of correct service is to ensure that the whole system is complete.

CONDENSER TESTING

Important Facts about Condensers

The condenser is one of the most important electrical components on the car; its function is to prevent arcing at the contact-breaker points. If the condenser fails, these points will rapidly burn, and the hole will make the engine inoperative.

The conditions under which the condenser operates are very stringent. The normal condenser can perform its duty in about $\frac{1}{10000}$ sec., and arcs only $\frac{1}{250}$ sec. to fire the complete number of cylinders.

Some indication of the importance of the condenser, and with it the contact-breaker points and coil, is to remember that these three units perform the complete operation six times as often as any one of the inlet or exhaust valves in a six-cylinder engine. The failure of any one of the three parts will make the engine inoperative, whilst it will still continue to run after a fashion even if several valves are out of commission.

It is a mistake to consider these small electrical components as comparatively unimportant.

It is equally important to remember the necessity of a proper balance being maintained between the components to ensure a satisfactory performance. Whenever a car is brought in for service a test should be made of the contact-breaker points, coil, and condenser.

Using Capacity Meter

The most satisfactory method of testing condensers is to use a capacity meter. An instrument which gives true readings in actual microfarads is very expensive to provide, and most service instruments used give a comparative microfarad reading on a graduated scale, where limits have been established by checking with various types of condensers known to be in thoroughly sound condition. These instruments, properly used, are quite satisfactory in determining whether the capacity of a condenser is sufficient for satisfactory performance.

The capacity of the condenser can vary through rather wide limits before it fails to prevent arcing across the contact-breaker points. Quite satisfactory performance may be obtained with condensers which vary in capacity between as much as ·15 to ·40 mfd.

For service requirements, cars of high-speed operation are usually fitted with condensers which have a capacity for lower limits; for cars with normal slow-speed performance, the condensers which give the best results are those with capacities near the higher loads. For normal operating conditions in standard pleasure cars the best results are produced by a condenser with medium capacity.

The capacity of the condenser is the main factor to consider. Insulation resistance is not so important. A resistance type of test should never be depended upon to determine the worth of a condenser. A reading down to 2 megohms is satisfactory, although many condensers will give a much higher reading than this.

Indications of Faulty Condenser

Lack of capacity is the most usual cause of condenser failure and resultant pitting of the contact-breaker points. This pitting can, however, be caused by a condenser which is of too low or too high a capacity, as well as by an actual failure of the condenser. It is not possible to check whether condensers are over- or under-capacity by any standard shop test. They should be allowed to operate for a few thousand miles before a check is made. If, after a few thousand miles' running, a tendency towards pitting is noticed, observe which contact point shows signs of pitting. If the system is earthed negative, the formation of a hole in the said contact point indicates that the condenser is under-capacity, whereas if the pitting took place in the arm it would suggest over-capacity. If the system is earthed positive, the position would be reversed. Do not place too much reliance on this rule, because such conditions as loose connections, high charging rates, or a condition of high voltage would affect the position.

of condensers a test used with success by many

the condenser with

If the substitution of the master condenser improves the performar new condenser should be fitted. It is also worth while, where the cost of the necessary equipment is not a handicap, to check the condition of the condenser by a capacity test, using reliable equipment. When making such tests the condenser should be jarred in order to show up any possible weakness due to loose connections, which are quite a frequent cause of trouble.

When replacing condensers, make certain that the replacement unit is of reliable manufacture, preferably of the same type and make as originally fitted on the car, and also take care to see that external connections are clean and tight.

THE ELECTRICAL EQUIPMENT ON THE MORRIS EIGHT AND TEN

MORRIS EIGHT (SERIES "E")

To obtain Access to Instruments and Windscreen-wiper Control Mechanism

FIRST disconnect the battery positive cable by releasing the pinch bolt of the terminal lug and withdrawing the lug from the post.

The starter-switch control wire should be released from its attachment to the scuttle just above the toe-board, and the mixture-control cable should be detached from the carburettor.

Disconnect the oil-gauge pipe by unscrewing the union nut attaching it to the oil gauge, and disconnect the speedometer cable from the back of the speedometer.

Remove the bakelite knob of the windscreen-wiper control by slackening its retaining grub-screw, and unscrew the central screw retaining the windscreen control handle on its spindle, withdrawing the handle.

The two screws at the top of the instrument panel and the two small hexagon nuts located at the back of the panel at the bottom should be unscrewed, thus releasing the panel, which can now be withdrawn sufficiently to give the necessary attention to the instruments or wiring.

Removal of Windscreen-wiper Assembly

The windscreen-wiper motor is released by removing the two nuts with plain steel and rubber washers from the inside of the scuttle, disconnecting the two wires from the motor, making a note that the lead coloured green and purple is attached to the terminal which is nearest to the scuttle, and easing the motor away from its attachment to the scuttle, towards the battery.

The wiper blade is released from its spindle by slackening the cheese-headed clamp-screw, enabling the arm to be withdrawn, together with the rubber sealing ferrule.

The drive spindle is released from its bracket by unscrewing the two retaining screws, which enables both spindles, together with the connecting link, to be withdrawn. For the purpose of reassembly it is wise to note that the green and purple wire is connected to the top and the black wire to the bottom of the switch terminal clip.

The connecting link is detached, when required, by removing the split

pin, steel washer, spring, and felt washer, which should be reassembled in the reverse sequence. It should also be noted that a felt washer is provided on each side of connecting link.

When reassembling the components it is important that the wiper blade should be correctly located on its spindle, so that it is parked on the offside and with the blade clear of the lower edge of the windscreen.

Removing the Windscreen Control

When the instrument panel is released, access is obtained to the windscreen control mechanism, which can then easily be removed by undoing the cheese-headed setscrew which attaches the control chain to the lug on the bottom of the windscreen, unscrewing the four screws attaching the forward end of the guide to the scuttle, and releasing the drive spindle from its bracket by undoing the two fixing screws, thus providing sufficient clearance at the forward end of the control to allow room for its extraction.

When replacing the control it should be noted that the four holes in the attachment bracket are elongated to permit proper alignment, and that the control position must be checked on reassembly before the attachment screws are finally tightened up.

Maintenance of Special Electrical Equipment

Most of the compensated-voltage electrical equipment fitted to the Series "E" Morris Eight follows normal Lucas practice, and is attended to in the manner described in the sections of the work dealing with Lucas equipment.

Headlamps

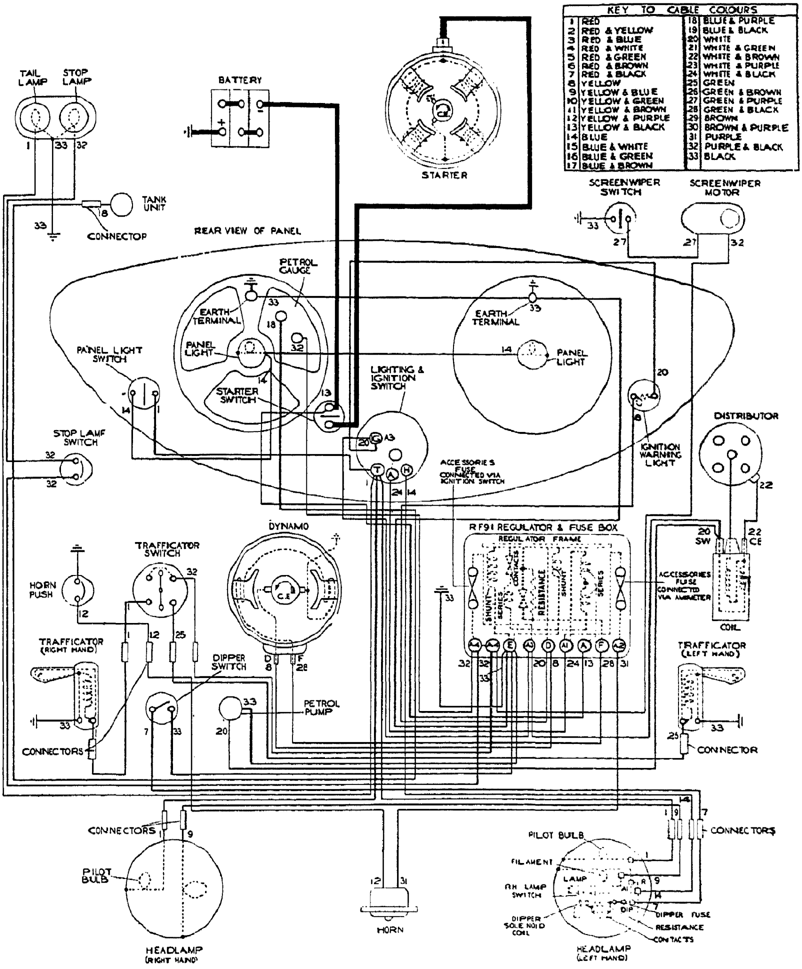
The main departure from normal practice is to be found in the headlamps, which are sunk into the wings and of special design.

These lamps are provided with dip-and-switch mechanism in which the nearside reflector dips on the operations of the switch, while the offside lamp is simultaneously switched off.

The dipping reflector and dipping mechanism follow normal Lucas practice, and need no further amplification here.

The proper focus of the bulb is attended to at the works and, provided it has not been interfered with and the correct Lucas bulbs are employed, the headlamp beam should be satisfactory. The correct bulb is a Lucas No. 106 of 6 volts, 24 watts.

If the bulb needs resetting at any time, this is achieved by removing the lamp front by unscrewing the attachment screw at the bottom of the rim, withdrawing the rim in an upward and forward direction, and setting the bulb in one of the three alternative notches provided in the bulb holder till the best illumination is obtained. It is essential after each adjustment to check the effect with the front in position, and the other lamp should be covered so as not to confuse the result.



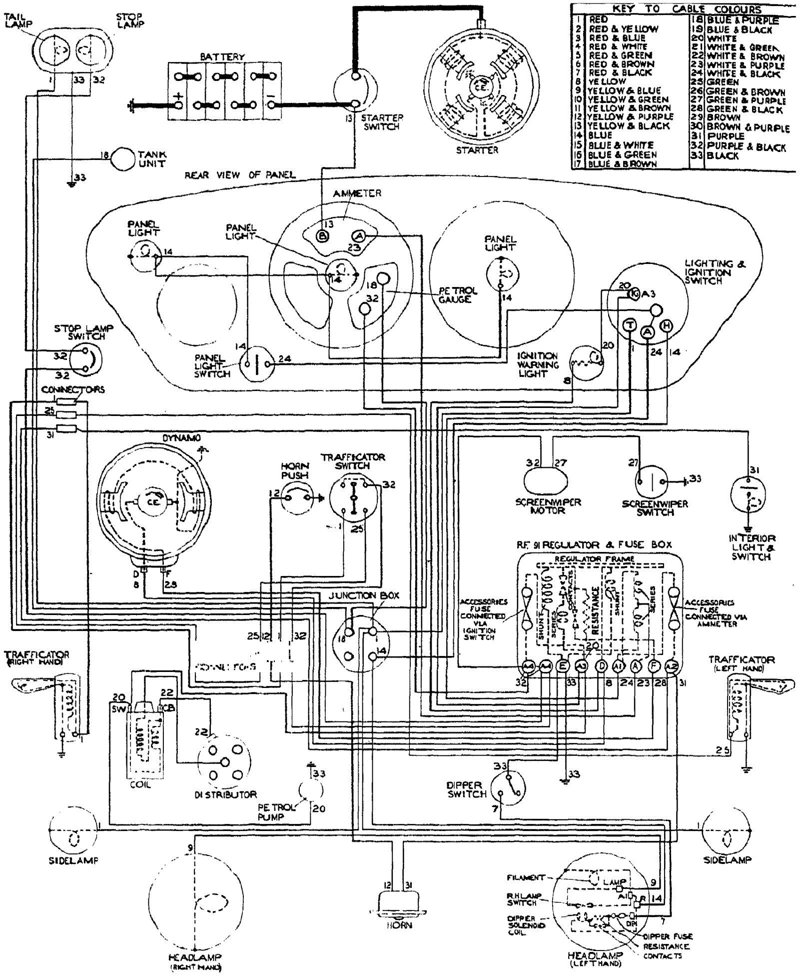
1.—WIRING DIAGRAM OF THE MORRIS EIGHT (SERIES "E") CAR

Lucas 6-volt electrical equipment is used, as follows

Dynamo : C45YV A108
Starter : M35G L2
Switch : PLC2 L47
Regulator and fuse unit : RF91 L
Battery : STXW9 E
Coil : 6Q6 L

Accessories fuse, 25 amps
Dipping reflector fuse, 10 amps
Bulbs : Main, No. 106 ; pilot, No. 200 ; "stop" tail lamp, No. 200 ; ignition warning light, No. C252A ; panel lamps, No. 200 ; trafficators, No. 255

(*Joseph Lucas, Ltd.*)



KEY TO CABLE COLOURS			
1	RED	18	BLUE & PURPLE
2	RED & YELLOW	19	BLUE & BLACK
3	RED & BLUE	20	WHITE
4	RED & WHITE	21	WHITE & GREEN
5	RED & GREEN	22	WHITE & BROWN
6	RED & BROWN	23	WHITE & PURPLE
7	RED & BLACK	24	WHITE & BLACK
8	YELLOW	25	GREEN
9	YELLOW & BLUE	26	GREEN & BROWN
10	YELLOW & GREEN	27	GREEN & PURPLE
11	YELLOW & BROWN	28	GREEN & BLACK
12	YELLOW & PURPLE	29	BROWN
13	YELLOW & BLACK	30	BROWN & PURPLE
14	BLUE	31	PURPLE
15	BLUE & WHITE	32	PURPLE & BLACK
16	BLUE & GREEN	33	BLACK
17	BLUE & BROWN		

Fig. 2.—WIRING DIAGRAM OF THE MORRIS TEN (SERIES "M") CAR

Lucas 12-volt electrical equipment is used, as follows :

Dynamo : C45YV L
Starter : M418G L
Switch : PLC2 L43
Regulator and fuse unit : RF91 L4
Battery : STXW9A or BNW9A
Distributor : DK4A A109
Coil : Q12 L

Accessories fuse, 25 amps.
Dipping reflector fuse, 6 amps.
Bulbs : Headlamps, No. 54 ; side, "stop," and tail lamps, No. 207 ; ignition warning light, No. C252A ; panel lamp, No. 1224M ; trafficators, No. 256

(*Joseph Lucas, Ltd.*)

Should the beam of the lamps be pointing too far upwards or downwards, or too much to one side, the alignment may be corrected, after removing the lamp front, by slackening the four hexagon-headed screws locating the lugs of the reflector to the lamp housing. The lugs are slotted for adjustment, and when the locating screws are released the reflector can easily be moved into the desired position.

Here, again, it is essential to test the results of the adjustment with the front replaced, before tightening up the locating screws.

If the Dipping Reflector Sticks

Should the dipping reflector become stuck in one position, examine the reflector pivots, and if they appear dry, lubricate with a drop of thin machine oil such as " Oilit."

If the bearings are free, examine the cables at the back of the reflector, and make sure that they are not fouling the reflector or dipping mechanism.

Another source of sluggishness is due to the plunger of the dipper unit sticking. This can usually be cured by applying the very slightest smear of thin machine oil on the plunger, and this is best carried out by damping a piece of cloth with the oil and wiping the plunger with it. Make sure that an excessive amount of oil is avoided or other troubles will beset the mechanism.

Damage or wear which upsets the setting of the actuating solenoid will often manifest itself by oscillation of the reflector. This is remedied by resetting the gap of the switch contacts, which should have a clearance of between ·010 in. and ·018 in. when the solenoid plunger is fully withdrawn into the solenoid. The switch gap is set by packing under the pin at the end of the plunger, as this adjustment is seldom called for.

MORRIS TEN (SERIES "M")

Balancing the Trafficator Switch

In cases of complaint that the self-cancelling trafficator switch is not functioning correctly in both directions, rebalancing of the self-cancelling switch may be necessary.

Attention to the switch should be carried out in the following manner :

Disconnect the positive terminal from the battery, and separate the wires leading out of the base of the steering column at the four connecters which are to be found just in front of the front offside engine bearer bracket. Unsolder and remove the four end caps from the wires.

Slide off the rubber sheathing from the cables and unscrew the hexagon nut from the tube projecting from the bottom cover of the steering-gear box. With a suitable drift of soft metal, carefully tap the bottom end of the projecting stator tube through the olive of the locking nipple as far as it will go.

This will enable you to withdraw the control disc in the centre of the steering into the car some 4 or 5 in., so that the switch mechanism at the upper end of the stator tube is exposed.

The front wheels should now be set in the straight-ahead position, and the trip ring located in the hollow centre of the steering wheel adjusted so that the knock-off cam is located exactly at the bottom of the wheel in the six o'clock position. This is effected by releasing the screw which passes through the side of the steering-wheel hub, thus pressing the trip ring, which can be moved into the desired position.

When the desired position has been attained, the locking screw in the hub should be tightened up again, enabling the stator tube and switch assembly to be pushed back into position with the switch at the top of the steering wheel at the twelve o'clock position, taking care to see that there is sufficient clearance between the baseplate of the switch and the steering wheel to prevent contact at this point.

The locking olive is next placed over the lower end of the stator tube where it projects from the bottom cover plate of the steering-gear box, followed by its hexagon nut, which should be tightened up while an assistant ensures that the switch assembly does not move at the upper end.

The caps may now be soldered to the wires and the wires reconnected to the connecter on the cable harness.

Withdrawal of the Instrument Panel

Remove the bakelite handles of the windscreen-wiper control by releasing the small grub-screw attaching them to their spindles.

Disconnect the positive cable from the battery by releasing the pinch-bolt of the terminal lug.

Unscrew the union of the oil-gauge pipe from the oil gauge, and release the speedometer cable from its attachment to the speedometer.

Unscrew the two screws at the top of the instrument panel and the two small nuts located at the back of the panel at the bottom, just below the speedometer and oil-gauge dials.

This will enable the instrument panel to be withdrawn, raising it to clear the control spindle for the speedometer trip.

The instruments are attached by bridge pieces or ring clamps, and their withdrawal presents no difficulty.

Removal of Windscreen-wiper Mechanism

In order to remove the windscreen-wiper mechanism it is first necessary to withdraw the instrument panel from the fascia board as already described, not forgetting to disconnect the positive cable from the battery.

Lift the offside bonnet panel and disconnect the two leads from the windscreen-wiper motor, noting for purposes of replacement that the purple-and-black lead is attached to the terminal nearest to the scuttle.

Remove the wiper blades from their spindles by releasing the cheese-headed attachment screws, and withdraw the rubber sealing ferrules.

Withdraw the dual-operating mechanism links by extracting the split-pins from the three bearing pins, noting that the correct order for reassembly is: felt washer, link, felt washer, plain steel washer, spring, plain steel washer, split-pin.

Remove the blade-spindle assemblies by undoing the two round-headed screws having spring and plain washers, which locate each spindle to its bracket. The offside spindle assembly incorporates the control switch, of course, and carries two leads for the switch.

Should the switch wires be disconnected at any time, remember that the top lead is the green-and-purple, and the lower lead the black one.

When reassembling, care must be taken to locate the wiper blades correctly on their spindles, remembering that the nearside blade should park on the nearside and the offside blade on the offside, and that the blades should lie clear of the bottom edge of the windscreen when in the parked position.

The windscreen-wiper motor is attached to the engine side of the scuttle by two long screws, and is readily removed by releasing these screws.

When replacing the motor, do not forget the insulating pad on which it seats.

COIL IGNITION

OPERATION, FAULT LOCATION, AND REPAIR

IT is essential to be fully conversant with certain fundamental electrical principles before those interested in the location and remedy of faults in coil-ignition equipment can be fully successful.

Principle of Operation

Fig. 1 shows a coil of wire connected across a battery through a switch. When the switch is closed a current will flow through the coil of wire. It sets up magnetic lines of force, as shown in Fig. 2, which are known as a magnetic field. If a piece of soft iron is placed in the centre of the coil, as in Fig. 3, the number of lines of force is increased, because iron is an excellent conductor of these magnetic lines of force known as magnetic flux.

Now, if we place a conductor in this magnetic field so that it forms a closed circuit (*see* Fig. 4), and place in this circuit a delicate measuring instrument, such as a galvanometer, we will find that at the moment that we connect the battery a momentary flow of current will take place, and similarly when the battery is disconnected a momentary current will again flow. In short, when a *change* in the rate of current flow through the coil connected to the battery takes place, a current is *induced* in the conductor through the medium of the magnetic field. It is to be clearly noted that current is only induced during the small period during which there is a *change* in the rate of current flow.

The amount of current induced in the conductor is dependent upon three things: (1) the number of magnetic lines of force with which it comes into contact; (2) their intensity, and (3) the rate of current change.

The Ignition Coil

If, therefore, we make the conductor take the form of a coil closely embracing, but insulated from, the coil connected to the battery, and give this second coil a large number of turns, obviously we shall obtain in it a very large induced current, which can be made very considerably stronger than the battery current. This arrangement is shown in Fig. 5.

Here we have an iron core composed of a bundle of soft iron wires, on which are wound several turns of, say, 20 S.W.G. enamelled copper wire insulated from the core; over the top of this, but in no way connected, are wound a great many turns of a much finer wire—say, 45 S.W.G.

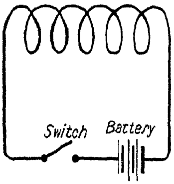


Fig. 1.—THE CIRCUIT AT REST

That is, the switch in the off position.

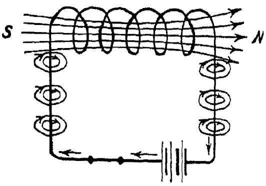


Fig. 2.—CURRENT FLOWING THROUGH CIRCUIT

Showing magnetic lines of force which are set up in coil at right angles to the current.

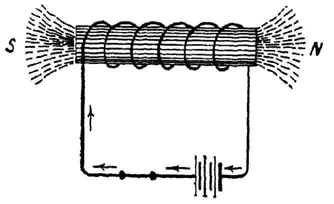


Fig. 3.—AN IRON CORE PLACED IN COIL INCREASES THE NUMBER OF LINES OF FORCE

enamel-covered—the two ends of this winding being brought out to a spark gap.

In order to identify the two coils, the one connected to the battery is known as the "primary coil," and the one in which current is induced is known as the "secondary coil."

The primary coil in practice consists of a few turns of relatively heavy-gauge wire, while the secondary winding consists of a large number of turns of fine-gauge wire.

How High Voltages are Obtained

In the case of the primary winding the current generated is very small, and is taken care of by means that are described later in this chapter. The current induced in the fine winding is, however, of a much higher value, owing to the great number of turns embracing the magnetic flux. For example, let us assume that the flux change is such that in one turn or loop 1 volt is induced. Then, if one thousand turns or loops are connected in series in the secondary winding, the voltage induced will be 1,000 volts.

The Contact Breaker

In practice a simple make-and-break switch, operated by a cam driven from the engine, is used to open and close the circuit of the primary coil, the opening and closing of this switch being timed to coincide with the point at which the spark is required. This switch is referred to as the "contact breaker," as in Fig. 6.

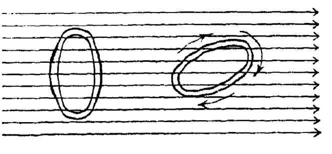


Fig. 4.—A CURRENT IS INDUCED IN A LOOP OF WIRE BY ALTERING NUMBER OF MAGNETIC LINES OF FORCE EMBRACED BY THE WIRE

In the sequence of events described and illustrated in Fig. 5, there would be no spark at the spark gap when the

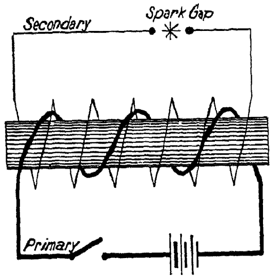


Fig. 5.—THE PRINCIPLES ILLUSTRATED IN FIGS. 4 AND 5 COMBINED

When the switch is opened a large voltage is induced in the great many turns of the finer wire. By means of the condenser shown connected in Fig. 7, this operation is made to cause a spark at the gap.

switch was opened, and the flux would fade away unless the gap was extremely small.

The reason for this is because the current in the primary winding still tends to flow when the switch is opened as indicated by an arc at the switch contacts. Once a current is set in motion it resists being brought to a standstill and acts as though it possessed weight, and, again, there is the induced voltage from the magnetic flux, which acts as a sort of back pressure. This current prevents a rapid fall of magnetic flux, and causes the flux to decrease slowly and become ineffective for inducing a high voltage in the secondary winding sufficient to jump the required spark gap.

Why does no spark occur at the spark gap when the switch is closed and the current in the primary magnetises the iron core, thereby changing the lines of force embraced by the windings ? Because the rate of change is too slow ; the primary takes a certain time to build up.

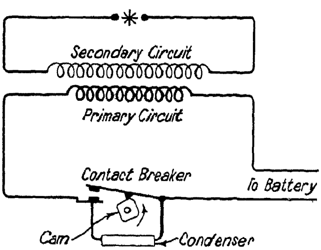


Fig. 6.—A CONDENSER ACROSS THE SWITCH OR CONTACT BREAKER IN THE PRIMARY CIRCUIT PREVENTS THE SPARKS OCCURRING AT THE POINTS WHEN THEY OPEN

Why a Condenser is Used

The secondary voltage is built up sufficiently to jump the spark gap by connecting a condenser across the switch or make-and-break. The condenser also prevents the spark occurring at the contact-breaker points when they open. Fig. 6 shows the addition of a condenser to the primary circuit.

A condenser in some respects resembles a reservoir. It is a device which absorbs and holds an electric charge, and gives off the charge when its terminals are connected in circuit.

The construction varies slightly according to requirements. A coil condenser is usually built up of alternate strips of tinfoil insulated from each other by waxed paper, each alternate strip of tinfoil being connected similar to the positive and negative plates of a battery, the waxed paper acting as the separators. To facilitate manufacture, the paper type of condenser is made in a long strip rolled up, fitted and sealed in a metal container and made practically airtight.

The magneto condenser is more open, and is constructed of alternate

sheets of mica and tinfoil, the whole assembly being pressed together and varnished.

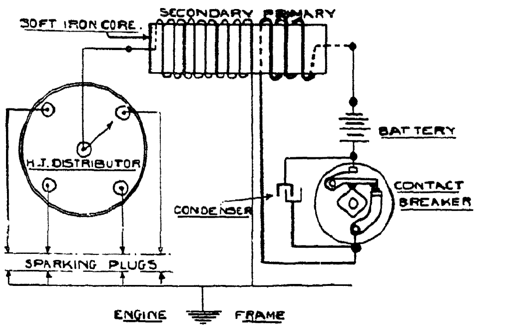


Fig. 7.—THEORETICAL DIAGRAM SHOWING ESSENTIAL PARTS OF A COIL-IGNITION SYSTEM

How the Condenser Works

The condenser offers an alternate and easier path to the current, which would cause the arc across the points. It brings the current in the primary to rest almost instantaneously, thereby causing the magnetic flux to fall to zero with great rapidity and induce a very high voltage in the secondary circuit.

At the moment the contact points open, the voltage from the primary across the condenser will be at its maximum and the condenser will become charged at this voltage, but the smallest fraction of a second later the voltage on the primary circuit will have begun to fall below the voltage of the condenser, and consequently the condenser will discharge itself on the primary winding in the reverse direction, and thereby further assist in bringing the primary current to a standstill. This sequence of events takes place with a rapidity that is almost beyond imagination.

IGNITION COILS

There are several types of ignition coils in use, but the underlying principles are the same for each. The variations are chiefly in the method of construction.

Current Consumption of Coil

The current consumption of the coil when the engine is running ordinarily is in the neighbourhood of 1 amp., due to the intermittent make-and-break. The faster the engine runs the lower will be the consumption of the coil, and vice versa.

The current consumed by the primary with the engine stopped varies from 5 to 10 amps., according to the make of coil.

The current consumption of a coil is less when the engine is running at high speed because the primary is in circuit over a shorter period of time, owing to the rapid make-and-break. As the speed of the engine increases the strength of the high-tension current decreases slightly, but providing that the correct coil and distributor are used, the high-tension spark avail-

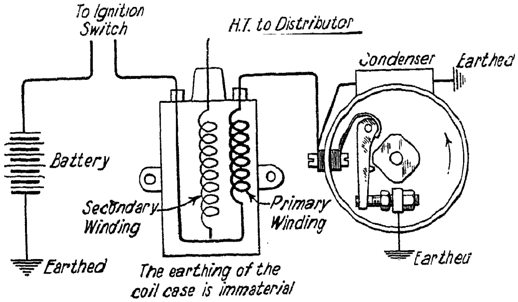


Fig. 8.—DETAILS OF AN EARTH-COIL-IGNITION CIRCUIT

Compare with insulated return system shown below.

able is well above its required intensity for the absolute maximum speed of the engine.

Internal Connections of Ignition Coils—Earth-return Coil

The secondary winding is connected to the primary if the coil is earth-return, as shown in Fig. 8. This has several advantages :

(1) It reduces the possibilities of the secondary winding breaking down and sparking on to the primary, because it is obvious that one end of the secondary has got to go to earth and act as the return for the high-tension current jumping across the plug points.

(2) The coil case does not need any particular attention in fitting by way of earthing to the frame of car ; and

(3) It obviates the possibilities of breakdown of the secondary to coil case.

It will, of course, be obvious that the secondary has a perfect path to earth through the battery and earthing strap.

Insulated-return Coil

The secondary of an insulated return coil is earthed to the metal case, because it is the only direct path to the frame of the car, and it is essential to see that this type of coil is efficiently earthed. It will be seen by tracing out the secondary circuit in Fig. 9 that the only way in which the high-tension current can go to earth is by way of the coil case or by leaking and jumping to earth through insulation of the lighting wires. If, therefore, the coil is not sufficiently earthed the secondary

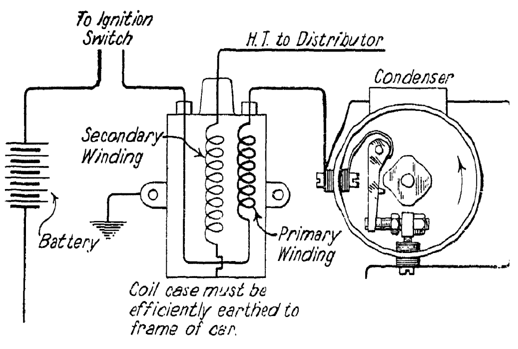


Fig. 9.—DETAILS OF AN INSULATED-RETURN COIL-IGNITION SYSTEM

has to find an alternative path to earth —this will put a strain on the secondary winding, which will result in the insulation breaking down on the winding, allowing the secondary current to jump to the primary and then to earth via the car wiring.

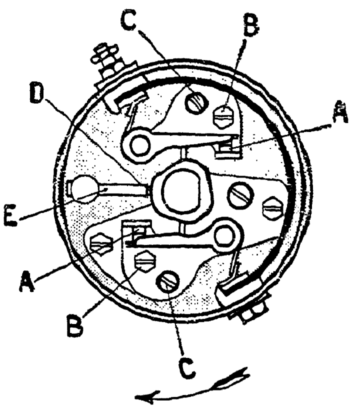


Fig. 10.—PLAN OF A DOUBLE-LEVER TYPE DISTRIBUTOR

A, contacts. *B*, locking screw. *C*, adjustment screw. *D*, wick lubricating cam. *E*, oil hole for cam-lubricating wick.

Operation of Contact Breaker

The contact breaker in Figs. 8 and 9 takes the place of the switch in Fig. 1. There will also be a controlling switch in the battery circuit for switching on and off. In each case the condenser is connected directly across the breaker points.

The rotating cam opens and closes the points, allowing the battery-current to flow through the primary winding. The number of lobes on the cam depends on the number of cylinders on the engine. A four-cylinder engine will have a four-lobe cam, a six-cylinder a six-lobe cam. There are, however, exceptions to this rule in the case of six-cylinder and eight-cylinder engines. The contact breaker in Fig. 10 has a three-lobe cam with two sets of contact points, which are arranged to open alternately. This arrangement is also used on eight-cylinder distributors.

Since each cylinder of a four-cycle engine fires once every two revolutions, it is obvious that the cam will run at half engine speed.

Having studied the principle and layout of the coil-ignition system, let us now proceed to examine defects and remedies.

FAULT LOCATION ON COIL-IGNITION SYSTEMS

Simple Lamp Testing Equipment

The most useful piece of testing apparatus for fault location on coil-ignition systems is a 12-volt, 24-watt S.B.C. lamp wired to a miniature lamp holder, and about a yard of twin flex.

See that Battery is Charged

In the following we are assuming that in every instance the battery is in a reasonably charged condition sufficient to supply the current necessary for the coil primary. This can be checked by switching on the lights and trying the self-starter. If this works satisfactorily without unduly dimming the lights, the battery may be judged to be satisfactory. It is as well to point out at this juncture, however, that very often the lights will

appear normal, but on using the starter they will dim considerably. When these circumstances obtain, starting should be done by hand, because the starter will be putting too big a load on a partly discharged battery, the result being too great a drop in voltage to allow the coil to function.

IF CAR REFUSES TO START

Is Primary Circuit in order?

The first thought in this case should be—is the circuit in order? This is usually indicated by the discharge reading on the ammeter, when the ignition is switched on. Should any doubt exist, however, this can be proved by removing the distributor cap and connecting the 12-volt test lamp across the contact points. The engine should then be cranked by an assistant and when the points open the lamp should light. As the points close again the lamp should go out. If no assistance is available, the opening and closing of the points may be done by flicking with the finger.

Indications of Defect in Wiring or Connections

When performing this operation, it should be observed that there is a definite clearance between the rocker-arm heel and cam when the points are closed. When using a 12-volt lamp on a 12-volt circuit, it should glow to full brilliancy when the points are open; this will indicate that the current passing is sufficient to work the coil. Should the lamp not glow to its full brilliancy, then there is a resistance in the circuit due to some defect in connections or wiring. It is, of course, obvious that a 12-volt lamp used on a 6-volt circuit will glow to only half brilliancy. Should you wish to use a 6-volt lamp for this test, a 6-volt, 18-watt is recommended.

Faulty-contact Points

If the lamp remains alight or dims slightly when the points appear closed, this indicates faulty contact at points, due to one or more of the following causes: sticking rocker arm (rusted or tight on fulcrum pin); badly burnt and oxidised contacts; rocker-arm heel not clearing cam in closed position (due to point gap being too wide).

The point gap should be not less than 15 thousandths, not greater than 18 thousandths (consult maker's recommendations).

Short-circuit or Open Circuit

A definite open circuit or short-circuit is indicated if the lamp does not light at all.

Testing for short-circuit

Remove the distributor battery wire and connect the test lamp in series with the battery wire and distributor terminal.

FAULT-TRACING CHART FOR COIL IGNITION

Symptoms	*Likely Causes of Trouble*
(A) Misfiring on one cylinder.	(1) H.T. cable detached ; (2) cable insulation faulty ; (3) wires broken in cable ; (4) plug fouled or faulty ; (5) plug gaps large ; (6) tracking over distributor surface—externally to earth—internally between segments.
(B) Misfiring irregularly on all cylinders at all speeds.	(1) Loose L.T. connection ; (2) dirt or moisture on distributor or ignition coil ; (3) contacts dirty, pitted, or worn ; (4) broken contact-lever spring ; (5) loose contact screw ; (6) tracking over between distributor segments ; (7) faulty ignition-coil H.T. cable ; (8) intermittent short on L.T. wiring ; (9) plug gaps large ; (10) plugs leaky ; (11) ignition coil faulty ; (12) condenser faulty ; (13) badly worn distributor brush and segments ; (14) battery connection loose or corroded ; (15) acid level very low ; (16) battery defective.
(C) Misfiring irregularly on all cylinders at high speeds.	(1) As B1, 2, 3, and 5 ; (2) contact gap large ; (3) plug gaps oversize ; (4) plugs leaky ; (5) ignition-coil cable faulty ; (6) as B13 ; (7) ignition coil faulty ; (8) intermittent short on L.T. wiring.
(D) Misfiring on hills or when accelerating, or timing retarded.	(1) Plug gaps large ; (2) plugs leaky ; (3) dirt or moisture on distributor or coil ; (4) contact gap large ; (5) tracking over between distributor segments ; (6) as B13 ; (7) ignition coil failing.

FAULT-TRACING CHART FOR COIL IGNITION—*Contd.*

Symptoms	*Likely Causes of Trouble*
(E) Misfiring at low speed and bad starting.	(1) Plug gaps small; (2) contact gap small; (3) contacts dirty, pitted, or worn; (4) poor L.T. connection; (5) battery connection loose or corroded; (6) acid level low; (7) battery discharged; (8) battery defective.
(F) Engine will not start (no spark from coil).	(1) Battery discharged; (2) battery defective; (3) battery connection loose or corroded; (4) open circuit in L.T. wiring; (5) ignition-coil H.T. cable faulty; (6) contacts dirty; (7) broken contact lever spring; (8) loose contact screw; (9) ignition switch faulty; (10) ignition coil defective; (11) condenser defective.
(G) Engine will not start (coil O.K.).	(1) Excessive moisture on plugs or distributor; (2) plugs very leaky due to moisture internally; (3) plugs fouled; (4) distributor-brush holder faulty.
(H) Low maximum road speed.	(1) Plugs leaky; (2) plug gaps large; (3) contacts dirty, pitted, or worn; (4) contact gaps large; (5) contact-lever spring weak; (6) ignition coil failing.
(I) Engine gets unduly hot.	(1) Ignition lever retarded; (2) automatic governor sticking; (3) incorrect timing; (4) plugs leaky.

If the short circuit is in the distributor, the lamp will remain alight all the time, and the trouble will most probably be traced to an earthing rocker arm, due to the arm having become loose on the bush and dropped on to the distributor base.

Testing for Open Circuit

When testing for any defect in a circuit, always start from the source of supply ; in this case, therefore, start from the ignition switch and not the distributor.

If the equipment is earth return, connect one wire of the test lamp to earth, remove the battery wire from the distributor, and be sure to keep it clear from earthing. Now with the switch on proceed to make contact with the other end of the test-lamp lead at all the available points in the circuit.

The first point would be the live side of the switch, then the coil side, next the switch side of the coil, then distributor side of the coil, and, lastly, the distributor wire at the distributor end. At every point contacted with the test lead a lighted lamp should result. If you come to a point, say, for instance, the distributor side of the coil, and find that no light can be obtained, but a light is obtained on the switch side of the coil, it is obvious that the break is in the primary of the coil.

Is Ignition-coil Secondary Circuit in Order ?

Let us assume that the ammeter in the very first instance has led us to assume that the primary circuit is in order. Our next consideration must be a defect in the secondary circuit.

A quick test may be made by removing the high-tension cable from the coil terminal and inserting in its place a piece of copper wire, or any other piece of wire that is handy, and arranging it in such a manner that it will allow the high-tension spark to jump to the frame of the car ; the gap should be about 5 mm.

The ignition should now be switched on and the engine cranked by hand or the self-starter, if satisfactory, and at each break a spark should jump the gap between wire and frame. The test may be carried out single-handed by removing the distributor cap and setting the points in a closed position and then flicking them with the finger.

If on making this test you find that no spark occurs at the gap, close it to about 2 mm. and repeat the operation ; if a spark occurs now, it is obvious that the coil is either very weak or there is some other defect in the circuit ; in all probability a faulty condenser or condenser connection. In this case the coil should be removed for further bench test. The same remarks apply to a coil that shows no spark at all.

Should the coil test be O.K., the next point to be considered is the high-tension circuit, and the following components should be carefully examined.

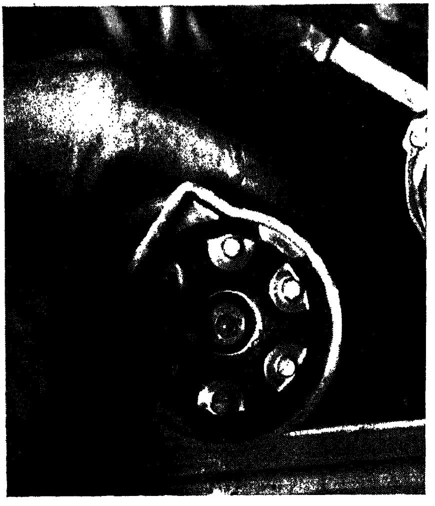


Fig. 11.—CONSISTENT MISFIRING ON ONE OR MORE CYLINDERS MAY BE DUE TO A TRACKING DISTRIBUTOR CAP

This can be located on sight by a thin black zigzag line, which looks like a crack, between two segments. It is caused by the spark jumping from one segment to the other instead of between the points of a faulty sparking plug.

High-tension Wire from Coil to Distributor

You will sometimes find that the terminal sockets are burnt or badly corroded at their base. This is due to the wire having been badly fitted and not pressed home. It is essential that the proper type of thimble is fitted to ensure proper contact. If the burning has taken place to any great extent, a new coil or distributor cap will be necessary.

Engine Misfires

Misfiring may be due to a weak coil, but is more often the result of some defect in the high-tension circuit, such as a tracking distributor cap or rotor. Faulty plugs or plug leads may be tested by removing the wires one at a time and testing for spark jumping to frame of engine. The wire should be held well away from the terminal end and allowed to jump a gap of about $\frac{1}{4}$ in. Do not allow the engine to run with a plug lead disconnected so that the spark cannot jump to earth, as this will put a strain on the coil and distributor cap and may result in a breakdown of the insulation.

Tracking Distributor Caps

Tracking distributor caps and rotors are often misleading, and will cause a consistent misfire on one or more cylinders. Usually a tracking distributor cap can be located on sight by a thin black zigzag line between two segments, which is often mistaken for a crack. However, on testing the cap with high-tension test leads the spark will be seen to jump or run across from one segment to the other. This is what actually happens when the engine is running, due to the fact that the resistance at the plug points in the cylinder under compression is much greater than the cylinder to which the adjacent segment is connected, the plug in this instance being on the exhaust stroke. The high-tension current, taking the line of least resistance, jumps back to the previous segment.

The majority of insulated distributor components are made from

bakelite. This material has a very hard and polished finish when removed from the mould, but should the surface be scratched or roughened it has a tendency to collect dust and moisture. Dust and moisture will, of course, collect in any case, but not to any great extent on a smooth surface.

In view of the foregoing remarks, it will be readily understood that the practice of attempting to rub out the tracking marks with emery- or glass-paper is absolutely useless, because the tracking will inevitably take place again in a very short time. Moreover, it will be observed that the actual track is very deep and is filled with carbonised powder from the effects of jumping sparks.

There is only one remedy for a tracking cap or rotor, and that is a new component. It is also very important to use only the genuine replacement parts to ensure the segments being in the correct position, the centre contact, the correct height and the rotor segment not fouling the distributor segment.

The Cause and Prevention of a Tracking Distributor Cap

The continual spark jumping the small gap between the distributor rotor segment and the cap segments in an enclosed air space results in the deposit of a nitrous powder in the cap ; this is, of course, conductive of electricity.

Most distributor caps of the jump-spark type are now ventilated in an endeavour to prevent this deposit. The cap should, however, be cleaned occasionally with water, which is a solvent of the nitrous deposit. The cap should be thoroughly dried before refitting. Do not wash the cap with petrol.

Other Causes of Misfiring

Other causes of misfiring are defective points, condenser, or sticking rocker arm. With regard to the contact points used on battery-ignition systems, these are tipped with tungsten or a tungsten alloy ; platinum is not suitable, and should not be substituted for tungsten with the idea of getting better results. The amount of current flowing in the coil circuit is much heavier than that in a magneto armature, and as platinum is a much softer material the points will quickly burn away when used on a coil-ignition distributor.

Defective Points

The defects to be looked for on coil-ignition contact-breaker points are pitted points, gap too wide or too close, and formation of a yellowish powder round the edge of the tungsten tips.

If the points are badly burnt or pitted, they can be refaced with a piece of emery-paper or an oil stone, but only as a temporary measure.

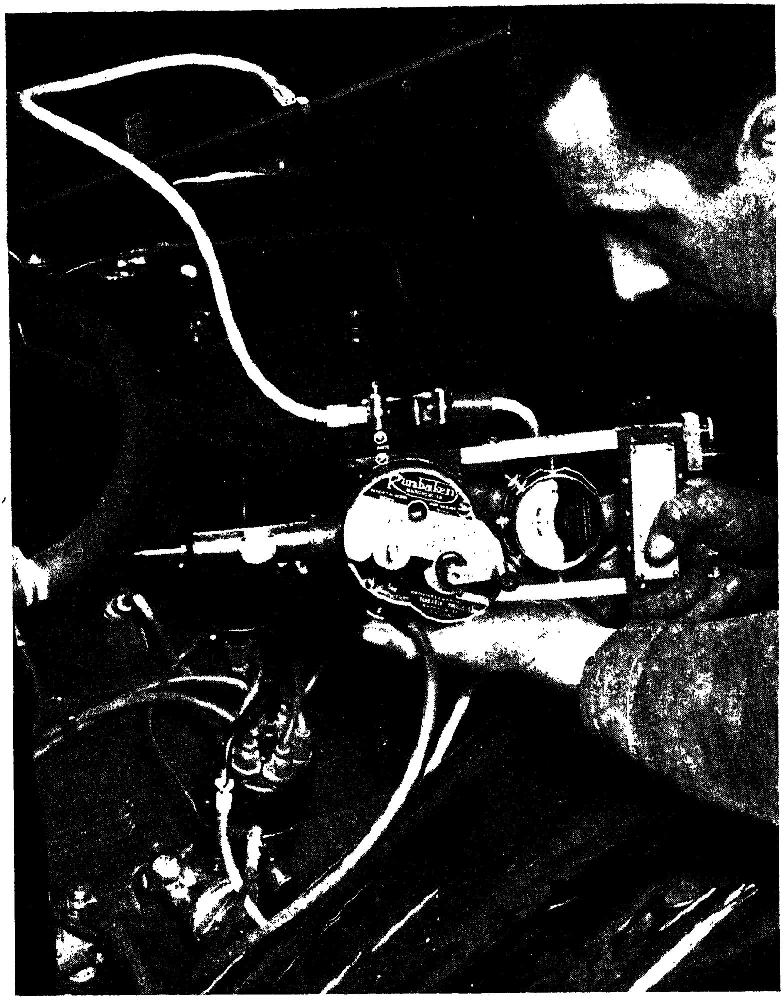


Fig. 11A.—TESTING A COIL BY MEANS OF RUNBAKEN HIGH-SPEED IGNITION AND BATTERY TESTER

The H.T. lead from coil to distributor is withdrawn from centre of distributor and is shown coupled to one point of the spark gap on top of the instrument. The other point is earthed. The remaining lead from the instrument is clipped to the L.T. wire from coil to distributor. With ignition switch on, rotate handle slowly and rapidly. Regular sparking across test-gap indicates a perfect coil. Intermittent or no sparking indicates a faulty coil. A condenser test is made with the machine coupled up in the same manner, but with a small condenser switch on the back of the machine placed "off." Other parts of ignition system can also be tested with this instrument.

The usual defect with tungsten points after they have been in commission for a period is the forming of a pip on the rocker-arm contact and a crater in the tip of the stationary contact.

Condenser Defects which cause Misfiring

Loose condenser connections, faulty earth connection, or weak condenser are causes of misfiring. The condition of the points is a good guide to the condition of the condenser. If the points are badly burnt the condenser should at once be suspected, and if there is a yellowish powder around the edges of the contacts the condenser is almost certain to be faulty.

Sticking Rocker Arm

This is invariably due to lack of lubricant on the fulcrum pin, resulting in the pin commencing to rust. The same effect can, however, be caused by the rocker-arm spring losing its tension.

Gap at the Contact-breaker Points

If the gap is too wide it will result in the points being open over a longer period, and consequently the primary will have less time in which to build up ; the ignition will also be slightly more advanced, due to the fact that the points will open sooner ; this may also cause the jump spark at the rotor to be too early and take place before the rotor segment and distributor segment are overlapping, and it will most certainly cause cutting out at high speed. You may also find that on some sides of the cam, if it is at all worn, the rocker-arm heel is not clearing properly.

This state of affairs invariably results in the burning of points, and also tends to retard the ignition. If the camshaft is at all worn, the points at certain speeds will not open on every lobe of the cam. The camshaft can be tested by setting the points in the fully open position and rocking the cam shaft to and from the contacts, noting the difference in the gap. In very bad cases you will find that the points can be opened and closed by this action.

BENCH REPAIRS AND SETTING

Having diagnosed the defects, let us now proceed with the method of bench repairs, and in doing so we will assume that our distributor is in a very bad state of repair, necessitating a complete overhaul. It is not practical to name one distributor in particular, so the following remarks may be applied to practically every type and make of unit.

Preliminary Test

It is a wise policy to run on test for a few moments the distributor that is to be repaired, in conjunction with your test coil, or its own coil.

The distributor should be coupled up to your testing apparatus and

" revved " up to at least 2,500 r.p.m., with the high-tension wires connected to a set of three-point spark gaps or other test equipment available. The preliminary test should confirm your diagnosis of the trouble on the car.

Now Dismantle

Let us now completely dismantle the distributor, and examine all parts with a view to assembling and replacing defective components.

Remove distributor cap, rotor, condenser, points, and breaker plate. Next remove driving gear and withdraw camshaft. In the case of units having automatic assemblies, the automatic assembly can, in most cases, be withdrawn separately from the cam driving shaft.

If the Cam is Worn, Replace It

The first component to be considered is the camshaft and cam. It is very seldom necessary to renew a cam owing to its having worn. However, if the cam is worn, do not attempt to reface it ; not only is this a waste of time when compared with the price of a new cam, but you will inevitably find on fitting a refaced cam that the points are opening unevenly on the different lobes of the cam.

The Automatic Advance Springs

If the distributor be of the automatic advance type, take care when reassembling to see that there is no excessive wear on the governor weight locating pins, and particular attention must be paid to the control springs. Do not on any account stretch these ; if they are already stretched they should be renewed by genuine replacement springs, otherwise the whole balance of the automatic mechanism will be thrown out of proportion with the speed of the engine.

Balance Weights

The baseplate to which the balance weights are pivoted should be closely examined for tightness. There have been occasions when this plate has been loose and caused no end of trouble by throwing the distributor out of timing with the engine.

The Contact-breaker Points and Rocker Arms

After fitting the camshaft assembly, the next operation is the fitting of the points. As mentioned earlier, automatics usually have a breaker plate on which the contact points and rocker arms are carried. The rocker arm, as a rule, is the insulated contact, and should therefore be tested when fitted to see that it is clear of earth. With some makes the insulated bushing in the arm is left proud to prevent the arm earthing on the underside. It is essential, therefore, to see that this bush is tight in the rocker arm ; a loose bush has led many mechanics astray, the

rocker arm having tested O.K. when first fitted, but after a short run has dropped and earthed on the distributor base.

How to Line Up Points which are Out of Square

The points should be set in line and square face to face. This is most important, especially with high-speed engines. If the points are found to be slightly out of line, they can be lined up by slightly setting the rocker arm or fixed contact support.

It is often necessary to fit the condenser at the same time as the points, owing to the methods of connections. Before fitting the condenser, however, it should be tested for a puncture or low capacity.

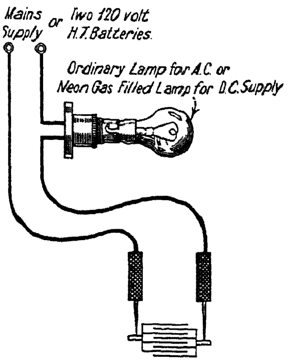


Fig. 12.—CIRCUIT FOR TESTING CONDENSER

The use of a neon lamp is to be preferred for this test.

Testing the Condenser

The usual method is to charge the condenser from the mains supply through a lamp, as in Fig. 12, then short-circuit the condenser with the test leads removed and note the intensity of the discharge spark. This test is not entirely satisfactory, and needs some little experience before one is able to judge the approximate condition of the condenser. Again, this method does not commend itself on alternating-current owing to the alternations. It is obvious that to leave the condenser in a fully charged condition you must disconnect your test leads at the moment the alternating-current cycle is at its peak.

The most efficient workshop method of testing condensers is perhaps the neon-gas lamp method. This can only be used on direct-current, and at least 200 volts is recommended.

The circuit is the same as in Fig. 12 for direct-current supply mains, but if this is not available two 120-volt high-tension wireless batteries will be found an excellent substitute, as the consumption of a 200/220-volt neon lamp is only about 5 watts; the batteries will therefore be doing no more work than that required for a three-valve wireless set.

The Neon-lamp Method

To test a condenser by the neon-lamp method, the test leads should be applied to the condenser connections in the ordinary way; immediately contact is made a charge will flow from the batteries or direct-current mains through the neon lamp to the condenser, resulting in the neon lamp flashing.

The terminal voltage of the condenser should now be equal to the mains voltage, and so long as it remains so, no further current will flow

through the neon lamp. Should, however, the condenser be leaking slightly, its terminal voltage will decrease and become considerably less than the battery or mains voltage. This will result in a further charge being impressed on the condenser, and the neon lamp will again flash. It will be seen, therefore, that the longer the condenser holds its charge the longer will be the period between each flash, and vice versa.

When considering this test, it must be borne in mind that there is no connection between the condenser and battery or mains when the neon lamp is not glowing, because there is no connection between the anode and cathode in the lamp.

In reviewing the above remarks, it will be understood that the number of flashes per minute will give a very good idea as to the state of the condenser. It should also be remembered that the test leads are in contact with the condenser throughout the test and need not be removed, as in the case of the charge and discharge test.

How to Interpret the Test Results

On tests with various condensers, it has been found from experience that a condenser may be considered fit for further service if it does not exceed sixty flashes per minute. Should, however, a condenser be found to flash with a greater rapidity, it must definitely be scrapped. A continuous glow on the neon lamp indicates a short-circuit across the condenser.

The capacity of condensers used in conjunction with coil ignition and magnetos varies from ·1 to ·2 microfarad.

The Distributor Cap and Rotor

Our next consideration must be the distributor cap and rotor.

There are three types of distributor caps now in use. The most common is the type in which the high-tension leads are fitted with a special metal thimble and pushed into a socket on top of the distributor.

Then there is the type having a nipple and screwed bakelite nut. Lastly, there is the waterproof type. With this type the high-tension wires are laid in grooves and pierced by a sharp pin above the respective distributor segment. A cover is then fixed over the high-tension leads, holding them in position.

What Defects should be looked for with Distributor Caps and Rotors ?

Burnt or corroded high-tension connections, worn distributor segments on distributor or rotor, faulty centre high-tension contact on distributor or rotor.

Tracking distributor or rotor.

Punctured rotor.

Cause of Burnt and Corroded H.T. Connections

This is generally brought about through the high-tension wire having been removed and not properly refitted. If there is any looseness or small air gap between the thimble on the end of wire and the metal of the socket in the moulding, a continuous stream of sparks will jump across the gap and will eventually burn the socket away.

The above symptoms are not noticeable in the early stages; the engine begins to misfire only when the trouble has developed usually beyond repair.

How Much Wear should be Allowed on a Distributor or Rotor Segment?

This is a rather difficult question to answer, owing to the fact that it is not possible to measure the gap with the components in position. It must be remembered, however, that the rotor segment does not make contact with the distributor segment, the air gap between the two being in the neighbourhood of $\frac{1}{32}$ in. Experience must play a big part in the adjudication of the renewal of distributor caps or rotors, and the following points must be borne in mind. First, the greater the gap the more intense will be the spark and the quicker will be the deposit of nitrous acid. Secondly, a greater strain will be put on the coil. Thirdly, the greater the gap the more rapidly will the segments burn until the point of misfiring is reached. We would recommend that a gap not greater than $\frac{1}{12}$ in. should be allowed.

How Can Faulty or Worn Centre Contacts be Repaired?

They cannot satisfactorily be repaired, and under normal conditions will outlast the life of the distributor cap or rotor. The only remedy in the case of a distributor cap is the renewal of the cap. With some rotors however, it is possible to fit new spring contacts when they are secured in position by a fixing screw.

How Can You Test for Tracking or Punctured Distributor Cap or Rotor?

This may be done by rigging up a high-tension test as in Fig. 15. To test for tracking, apply the test prods to the adjacent distributor segments in turn, and if tracking is taking place the high-tension spark will jump from segment to segment in preference to jumping across the test-spark gap. The same remarks apply to punctured or tracking rotors. After a few tests with this apparatus various other uses will be suggested to the operator.

H.T. Test

There are various methods of devising a high-tension test, but the most efficient is without doubt the rotary make-and-break method in conjunction with a coil. This test can also be used for testing coils and magneto armatures. There are various makes of test sets on the market

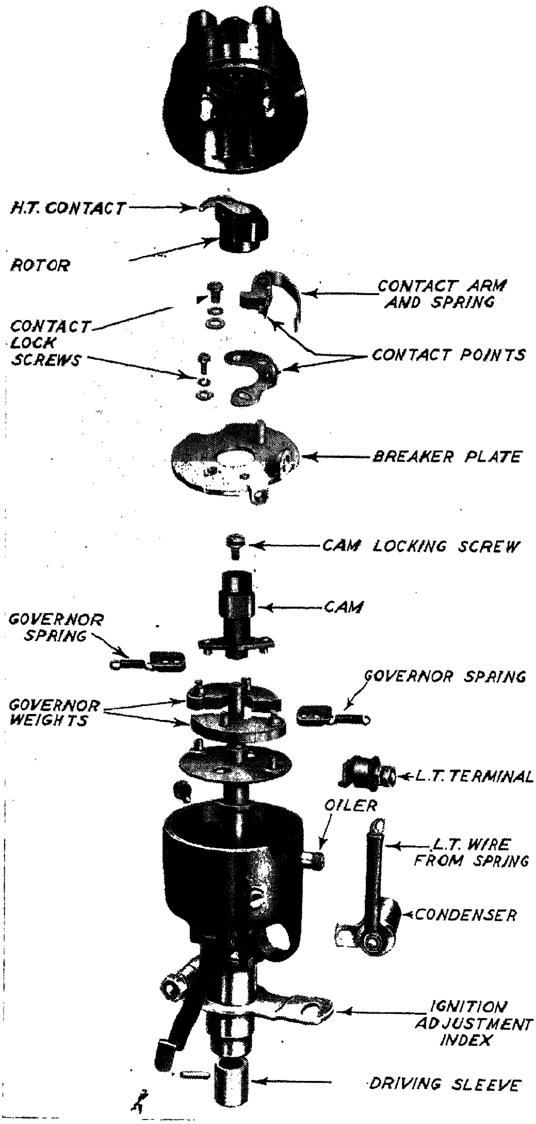


Fig. 13.—Exploded view showing parts of automatic-advance distributor

which are designed for coil, magneto, and high-tension tests, typical examples of which are described in other articles. For the benefit of those wishing to make up their own test we give here the wiring circuit and layout (*see* Fig. 14).

The Final Assembly of Distributor

The distributor is now ready for final assembly and test; the point gap should be finally checked up, and when fully open should be approximately 18 thousandths.

When fitting the rotor and distributor cap it is advisable to check up the relative positions of the cap and rotor segments, as follows:

Mark the position of the distributor segment on the distributor housing with a pencil; fit the rotor in position and rotate the cam in the required direction until the points begin to open; the distributor-rotor segment should then be overlapping the

distributor segment, as in Fig. 15.

In the case of automatic-advance distributors, where the cam is automatically advanced, the rotor should be just overlapping on the trailing edge of the distributor segment as the points are opening in the retard position, and just overlapping the leading edge when in the advance position.

The unit is now ready for a final running test, and should be capable of giving at least 12,000 sparks per minute without missing.

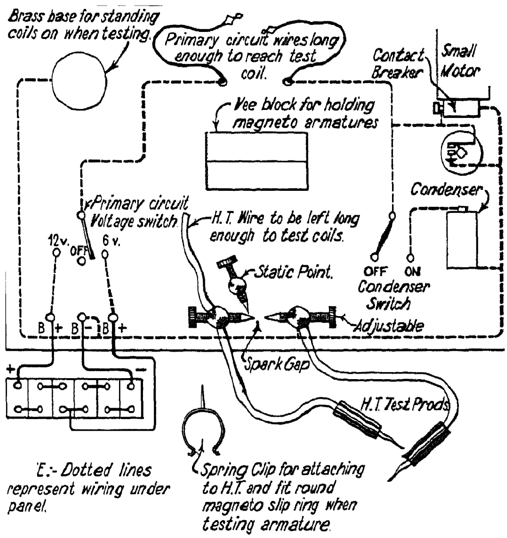


Fig. 14.—HIGH-TENSION TEST SET FOR TESTING IGNITION COILS AND DISTRIBUTORS

Ignition-coil Bench Tests

If a spark-jump test is used for coils, the spark should jump a gap of 5·5 mm. at all speeds up to at least 2,000 r.p.m.

If a buzzing is heard coming from inside the coil under test, a loose core is usually the cause.

When testing a coil, the case should be tested by earthing it to the return side of the battery. This will show up an earthing primary or leaking secondary. The right-hand test prod in Fig. 14 will act as earthing wire if placed in contact with coil case under test. It is also useful for testing distributor top for tracking.

Distributor Design

Owing to the great number of models, it is impossible to deal with each model individually. In most cases the difference is due to a different design of the rocker arm, rotor, or distributor cap. The general principles remain the same.

Distributor units can generally be divided into five classes :

(1) Single rocker arm, manual advance.
(2) Single rocker arm, automatic advance.
(3) Twin rocker arm, manual advance.
(4) Twin rocker arm, automatic advance.

(5) Twin rocker arm, alternate make-and-break, automatic and manual advance.

A Warning *re* Distributor Springs

Those in class (2) are now the most common type in use. Their construction is too well known to need explanation. There is one point, however, that must be borne in mind. Never alter the spring-tension arrangement of the automatic, and when renewing springs always be sure to fit the genuine replacement parts which have been designed and tested by the manufacturers to give the correct amount of advance at a given speed.

Distributors in classes (3) and (4) are now being superseded by those in class (2), owing to the great advance in coil construction.

The two rocker arms are in parallel, and should be set to open synchronously. The adjustment allowing this setting is carried out by an eccentric screw passing through the base of the plate carrying the contact point, the contact plate being finally locked in position by a fixing screw.

Why Twin Rocker Arms are Sometimes Used

The object of fitting twin rocker arms will be obvious after a moment's consideration, for it will be seen that they allow double the area of contact, and in consequence reduce the resistance in the primary circuit of the coil and allow it to build up in a shorter space of time. This type of distributor unit was designed to suit the requirements of the high-speed engine, and as a matter of interest the reader can remove one of the rocker arms from this type of distributor and run the distributor with one rocker at high speed on the test bench, taking note of the maximum speed at which missing takes place, then refit the other rocker arm and repeat the experiment, when he will find that a much higher speed can be obtained before missing takes place.

Unbalanced Automatic-advance Weight Springs

One of the pioneers of this type of distributor was Messrs. Delco-Remy, and the majority of the distributors manufactured by this company were designed with automatic advance combined with manual advance. The automatic counter-weights are held in position with small coil tension springs, and you will note that on some distributors the springs are of two different sizes. This has often misled the repairer, who has assumed that somebody at some time has fitted an incorrect spring as a temporary measure. This is not so, however. The springs have been so calculated to allow for a quick advance on the weaker spring up to a certain speed ; after this point the advance has been slowed down to prevent over-advancing. A distributor of this type was fitted as standard on the Talbot car.

Rocker Arm Alternate Make-and-break

Distributors in class (5) are easily recognised by the fact that the cam has half the number of lobes to cylinders, a six-cylinder cam having three lobes and an eight-cylinder having four lobes.

The rocker arms are placed so that they open alternately. A study of the sequence of events will soon make clear the object of this arrangement, for it will be seen that the points are in contact over a period twice that of the contact on the six- or eight-lobe-cam distributor. This arrangement, again, allows more time for the primary to build up.

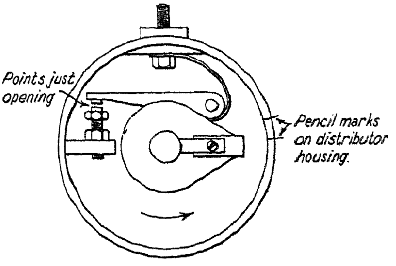


Fig. 15.—HOW TO CHECK UP THE RELATIVE POSITIONS OF THE CAP AND ROTOR SEGMENTS

Mark the position of the distributor segment on the distributor housing with a pencil; fit the rotor in position and rotate the cam in the required direction until the points begin to open. The distributor rotor segment should then be overlapping the distributor segment.

Great care must be exercised when adjusting the points on this type of distributor to see that at no time are both sets of points in contact at the same moment, as this would cause the primary circuit to remain closed, as one set of points would have opened after the other set had closed. When rotating the camshaft by cranking the engine, one set of contacts will be open, and just as they are about to close the other set should open; continue cranking, and as the second set are about to close the first set opens again.

If an engine fitted with this type of distributor is reported to be missing on three or four cylinders, as the case may be, the trouble will invariably be traced to one set of points not opening before the other set is closed. A further adjustment is provided with this type of distributor by way of movement of the complete contact-breaker baseplate assembly.

How to Remove and Refit a Distributor Head Unit

Before removing the distributor, the procedure should be as follows:

(1) Crank the engine until No. 1 cylinder is on the compression stroke.

(2) Advance the ignition lever, if fitted, or set the micrometer adjustment of an automatic distributor to zero. Crank engine *slowly* until contacts are just about to open. Observe the position of the distributing electrode, and make a mark on the distributor casing directly opposite the electrode.

(3) Carefully note the position of the flywheel or the distance No. 1 piston is down the cylinder on the compression stroke.

(4) Remove the distributor and label the plug leads Nos. 1, 2, 3, and so on, according to the order of connection to the distributor. No. 1 plug

lead will, of course, be that connected to No. 1 cylinder sparking plug. The order of connection to the distributor will be that in which the distributing electrode passes the segments for normal rotation.

(5) Disconnect the plug leads from the distributor, and also the control-rod connection from the timing lever.

(6) Remove the screw retaining the distributor head in its seating.

Generally, this will be a screw passing through a slot in the timing lever and having a spring under the screw head to hold the timing lever down by spring tension. Since the timing lever is clamped around the shank of the distributor head, this unit is also held in its seating. In some cases a setscrew locating in a groove in the shank of the distributor head serves to retain the unit in position. This screw will be found in the side of the distributor head seating.

(7) Withdraw the distributor-head unit.

Upon reinstallation, the distributor head will probably be refitted without any difficulty if the engine crankshaft has not been disturbed since removal of the distributor head. If there is any doubt upon this point proceed as follows:

(1) Set crankshaft for No. 1 piston position for timing as determined prior to removal.

(2) Turn the distributor-head spindle so that the electrode is opposite the mark made on the casing.

(3) Insert distributor head in its seating with the timing lever, if fitted, in position for connecting up to the control rod when the latter is fully advanced.

(4) Note whether contacts are just on point of opening. If the gears are correctly meshed this will be the case, and the electrode will also be opposite the mark on the casing. If it is not, try remeshing the gears until the desired position of electrode is obtained.

(5) Should it not be possible to refit the distributor head with the electrode correctly positioned, the nearest gear meshing should be obtained.

(6) Fit the distributor-head retaining screw and loosen the timing-lever clamping screw. Now turn the distributor head until the mark on the casing and the electrode are coincident and so that the contacts are just about to separate. Then tighten the timing-lever clamping screw.

(7) Reconnect the plug leads to the distributor in order of rotation of the distributing electrode, making sure that No. 1 plug lead is correctly connected to the terminal, the segment of which is adjacent to the electrode. Refit the distributor.

C.A.V. ELECTRICAL EQUIPMENT

SWITCHBOARDS, SWITCH PANELS, SWITCHES, AND ACCESSORIES

A WIDE range of C.A.V. switchboards and switch panels are in use, and they vary considerably in size and shape according to the class of service for which they are intended. In the following, the types dealt with are those in most common use and which are likely to be met with frequently.

SWITCHBOARDS

Switchboards usually provide the means for controlling lighting, starting, and ignition in conjunction with compensated voltage-control equipment. The smaller types will often be found assembled into large panels, together with instruments such as speedometers, oil gauges, etc., which form conveniently grouped units for building into the vehicle dashboard. Some panels are also arranged for clamping to the steering column, an arrangement which is particularly suitable for vehicles arranged for forward control when space is often very limited.

Dynamo Warning Light

On the majority of switchboards a red dynamo warning light is fitted, which is controlled by the ignition or pilot switch, and operates as follows :

It lights immediately the ignition or pilot switch is turned to the "ON" position, and remains alight until the dynamo reaches cutting-in speed. The lamp will relight when the dynamo speed drops below cutting-out speed, or if for any reason the dynamo ceases to generate.

With coil ignition and engine stationary it indicates that the battery is discharging through the ignition coil.

Starter Switch

The small starter switch fitted to some boards does not carry the main starter current, but a small current required to operate the solenoid switch mounted on or near by the actual starter.

Replacement Bulbs

It is important, particularly with dynamo warning lights, that replacement bulbs are of the same voltage and wattage as those originally fitted.

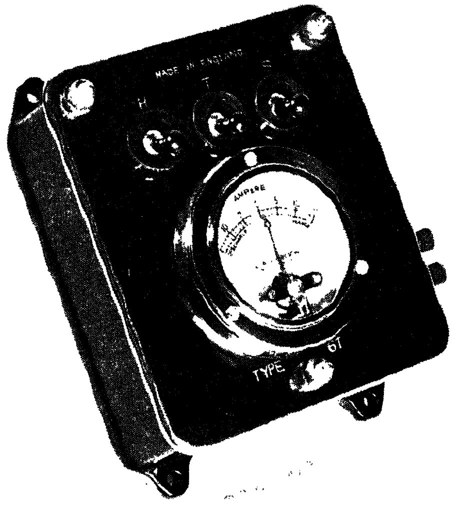


Fig. 1.—C.A.V.-TYPE 6T SWITCHBOARD

Switchboard Type 6T

For use with small compensated voltage-control dynamos, this is a rectangular board, fitted with three switches controlling head, tail, and side lights, a double-reading ammeter, two-pin plug sockets, and main dynamo fuse (*see* Fig. 1).

The ammeter is permanently connected in the battery circuit, and its reading indicates the state of charge of the battery. With a fully charged battery and the dynamo charging, a small discharge will be indicated if all the driving lights are switched on, owing to the fact that for a short time the battery voltage equals or slightly exceeds the dynamo voltage. As the battery voltage settles down, the whole of the load discharge is taken by the dynamo, and the ammeter needle will gradually move over to indicate a small trickle charge into the battery. The ammeter will indicate the highest charging rate when the battery is discharged. The ammeter does not register the current taken by the road lamps when the dynamo is charging, but indicates this discharge current only when it is actually being taken from the battery ; that is to say, either when the dynamo is running too slow to charge or when the engine is stationary. The ammeter will not register the discharge current taken by any other accessories beyond the driving lights, as they are not included in the ammeter circuit.

Unless the fuse is intact and in position, no charging current will reach the battery, as the fuse is located in the main dynamo circuit.

Maintenance of Type 6T Switchboard

The fuse wire can be replaced by withdrawing the fuse bridge from its clips and inserting one strand of wire between the spring copper contacts in the fuse bridge. Spare fuse wire is located in the small envelope clipped to the side of the switchboard. No. 30 S.W.G. copper must be used and strictly adhered to.

Smear occasionally, with a thin film of vaseline, the switch-handle ball portion and rollers.

Switch blades and spring contacts should be kept clean with fine carborundum paper.

Switchboard Type No. 47

This is a popular circular type of switchboard intended for flush fitting into a dashboard or panel. If sufficient slack has been allowed in the cables, the complete board may be withdrawn from the front of the dashboard by removing the back clamp.

The board is fitted with a main rotary switch for the control of the side, tail, and head lamps, together with an additional turn switch for ignition control. Either magneto or coil may be used, but it is not suitable for dual ignition. Dynamo charging is indicated by a red pilot light fitted to the right of the ignition switch.

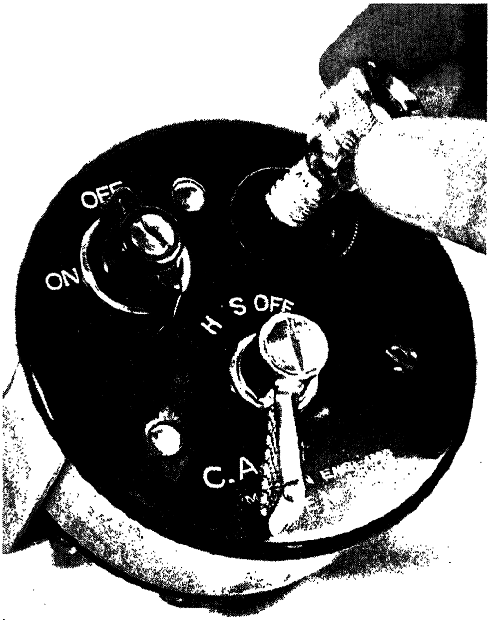


Fig. 2.—Removing pilot-lamp bulb from No. 47 switchboard

Marked terminals are fitted at the rear of the board for cable connections to the positive and negative feeds, as well as for all driving, ignition, and pilot lights.

An aperture $3\frac{7}{32}$ in. (82 mm.) diameter is recommended, to accommodate the board in the dash panel.

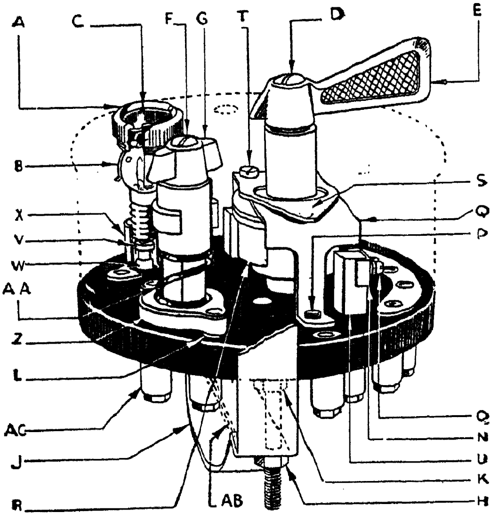
Operation of Type No. 47 Switchboard

Both the main and ignition switches are operated by turning to the positions clearly marked on the faceplate.

To replace Pilot Lamp

Unscrew the bezel (*A*) (Fig. 3) holding the red pilot glass from the front of the board, and the bulb will be automatically withdrawn by the means of a spring clip (*B*) located in the bezel and gripping the glass bulb. The voltage and wattage will be found marked on the bulb cap.

It is advisable to use bulbs obtainable from C.A.V., as they are the correct size to suit the spring clip, and so eliminate any danger of the



3.—No. 47 SWITCHBOARD ASSEMBLY WITHOUT BODY AND FACEPLATE

prongs touching the live bulb cap.

The pilot lamp glass (*C*) can be replaced by removing the spring clip (*B*).

To dismantle the Board for Cleaning or Replacing Contacts

The complete board should be removed from its faceplate or dash panel, and all cables disconnected. Referring to Fig. 3:

(*a*) Remove fixing screw (*D*) and main switch handle (*E*).

(*b*) Remove fixing screw (*F*) and ignition knob (*G*).

(*c*) Remove fixing nuts (*H*) and clamp (*J*).

(*d*) Remove fixing nuts, spring washers, and plain washers (*K*).

(*e*) The terminal base can now be removed from the body.

Take care that the ignition-switch parts are not lost, as they will be liable to fall out when the body is removed.

(*f*) Examine ignition-switch contact pins and locating sockets (*L*). Clean with very fine carborundum paper if they are in a dirty condition. Examine the fixed main contacts (*N*). They can be easily removed by unscrewing the one screw (*O*). If dirty, clean as above; take care not to bend them out of shape, and make sure they make good contact when replaced. If badly burnt, bent, or pitted, replace.

(*g*) The main rotor contact can be cleaned by first extracting the two screws (*P*) from the back. This will allow the removal of the bracket (*Q*) from the rotor (*R*). Take care not to lose the locating steel ball (*S*). Clean the contacts if necessary, but replace if badly burnt or corroded. See that the screws (*T*) holding the springs are perfectly tight.

(*h*) If the brass pillars (*U*) holding the contacts have become loose, tighten by means of the countersunk screw located in the respective terminal on the back of the base, and which is accessible after removing cable screw.

(*j*) Examine the lamp-holder plunger (*V*), clean the tip if dirty; a few drops of oil in the socket (*W*) will ease any stiffness, but keep it away from the plunger tip. See that the small pressure prongs in the side of

the lamp-holder (*X*) have not been bent out of place so that the locating pressure on the lamp is lost.

Reassembling the Type No. 47 Board

Smear the rotor-bearing pin with vaseline, and locate the rotor in the metal base bush, so that the square is parallel with both the horizontal and vertical axis of the switchboard when it is in the normal mounting position, and the small contact is across the two fixed spring contacts, i.e. when the switch is in the maximum "ON" position. After coating the steel ball with vaseline, place it in the locating hole on the stop plate, that is, on the horizontal centre line. Place the bracket (*Q*) over the rotor, so that the small hole locates over the steel ball; fix from the back with two screws (*P*).

Locate the ignition-switch contact piece (*Z*) so that the contact pips bridge across the C + and B + sockets, i.e. in an almost vertical position. Place the spiral spring (*AA*) over the square portion of the moulded ignition rotor and locate it in the square of the contact piece (*Z*), so that the flats of the brass hexagon on top of the rotor are parallel with the vertical centre line of the switchboard, and the cut-away portion of the moulding points towards the main-switch spindle.

Replace the body and switch handles in the reverse order of the dismantling instructions, (*a*), (*b*), (*c*), and (*d*).

On boards fitted with the flat-type clamp, always replace the insulator (*AB*) before the clamp.

Switchboard Type No. 85

This is a rectangular proud mounting board for control of starter, ignition, and all driving lights. A red dynamo warning light, two-pin plug sockets, and fuses are also fitted (*see* Fig. 4).

A separate fuse is connected to each light and ignition switch, whilst an additional fuse for use with any auxiliary accessories is connected to the main positive feed, which is not controlled by any switches.

Terminal screws are accessible from the front if the switch housing is removed.

A hinged cover is provided to permit attention to be given to the fuses from the front of the board, and also to allow the two fixing screws to be extracted for the removal of the housing.

The dynamo pilot-light bulb is automatically withdrawn with the bezel containing the red glass when the bezel is unscrewed.

The main control switch must be on before any lights can be operated.

For the operation of the red dynamo warning light, *see* p. 561.

The two-pin plug sockets are permanently connected to the positive and negative feeds, and are not affected by any switches.

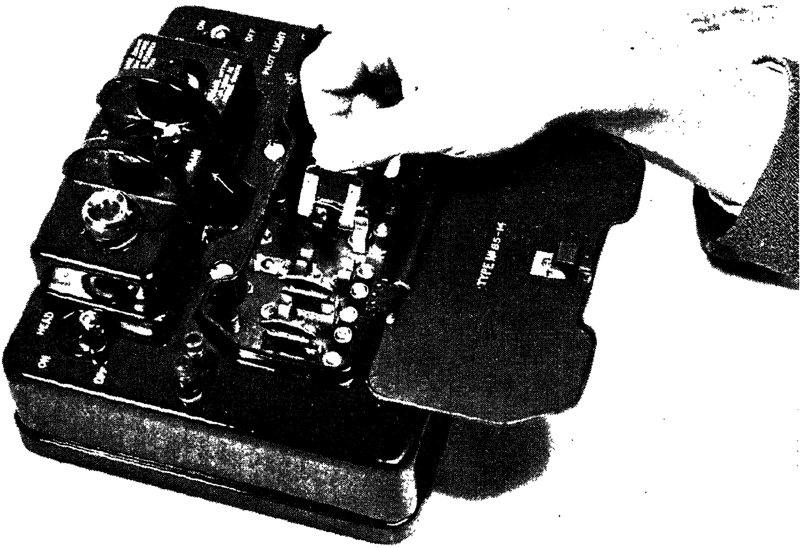


Fig. 4.—Extracting fuses from No. 85 switchboard

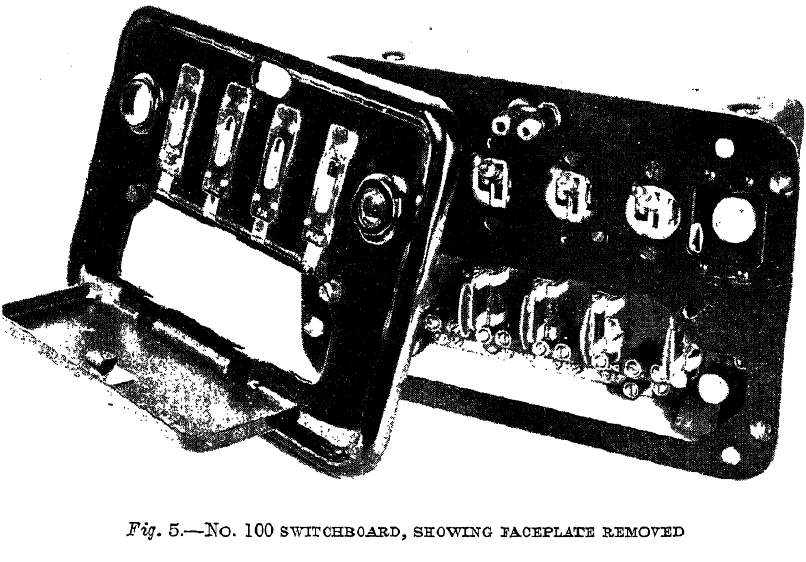


Fig. 5.—No. 100 switchboard, showing faceplate removed

Maintenance of Type No. 85 Board

Attention should be given periodically to the main switch, as explained on p. 568 for the No. 101 switchboard, and to the light switches as given for the No. 6T on p. 563.

The ignition-switch contacts and spring should be kept very lightly smeared with vaseline.

See that the fuse bridges are secure in their clips. The fuse wire is No. 32 S.W.G. silver (·011 in.). A spare length is supplied wound around the fuse bridge.

If the red pilot-lamp glass is broken, a replacement can be fitted by releasing the spring bulb holder inside the bezel.

Switchboard Type No. 86

This five-way board is intended for controlling accessories other than driving lights. It is designed to work in conjunction with the No. 85 or No. 100 boards, and can be used as a separate unit if desired.

Six fuses are provided, one for each switch, and a single one mounted independent of all switches for use with auxiliary accessories.

Maintenance details are similar to those given for type No. 6T board. The fuse wire for type No. 86 is No. 32 S.W.G. silver.

Switchboard Type No. 100

Similar to No. 85, this master board is for flush mounting, and is fitted with type No. 99 snap-action switches.

No switches will function unless the switch marked "MAIN" is switched on.

Any single switch can be removed after extracting the two fixing screws in the sub-plate, and the connection screws. At intervals apply thin machine oil sparingly to the switch-bearing pins through the holes in the sub-plate.

Vaseline the spring and plunger, spring ball, leverage face, and sliding splash plate.

Keep the switch blades free from dirt by using very fine carborundum paper or spirit. The switch should be replaced if the blades are badly burnt or pitted. Smear the switch blades very lightly with vaseline.

See that the fuse bridge is located firmly in the fuse clips. Fuse wire is No. 32 S.W.G. silver (·011 in.). A spare length is supplied wound around the fuse bridge. The "AUX" fuse is independent of all switches, and is located in the positive connection to the two-pin plug sockets.

Switchboard Type No. 101

This board is rectangular in shape (*see* Fig. 6), and serves a similar purpose to the No. 47 circular switchboard. It controls all driving lights and ignition and is fitted with a dynamo warning light.

The faceplate can be removed if the three front screws are extracted.

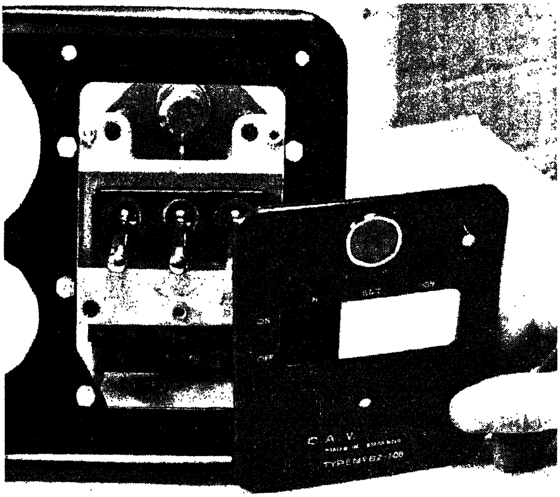


Fig. 6.—REMOVING FACEPLATE FROM No. 101 TYPE SWITCHBOARD

Either magneto or coil ignition can be used with the No. 101, but not both.

Lubricate occasionally the switch hinge-pin, plunger roller, plunger, and dolly bearings with thin machine oil applied sparingly. Also smear the plunger-roller bearing surface on the switch blade and the contact tips very lightly with vaseline.

Keep the switch blades and contacts perfectly clean with very fine carborundum paper or spirit.

If the blades are badly burnt or pitted, they should be replaced. To replace the blades, extract the four screws to release the sub-plate complete with the dollies and plungers. Remove the split-pin in the bearing pin and extract the bearing pin to release the blade.

SWITCH PANELS

C.A.V. switch panels incorporate a switchboard together with instruments. They are, as a rule, fitted with a form of internal illumination, which lights up the dials of the instruments for night driving.

Switch Panel Type No. 54

Switch panel No. 54 is arranged for flush mounting; this is an oval-shaped panel held in position in the dashboard by rear clamp-brackets (Fig. 7).

All terminals and internal-illumination bulbs are accessible from the front of the panel if the small cover plate is removed.

For maintenance of the No. 47 switchboard contained in this panel, *see* p. 565.

Switch Panel Type No. 65

Type No. 65 is a panel specially designed for clamping on to the steering column of the vehicle. This panel is also fitted with the type No. 47 switchboard.

Indication of an interruption in the engine-oil flow when the engine is running is shown on some boards by the green warning light being extinguished.

If a dipswitch is mounted on the side of the panel it should dip the headlamps when moved to the "ON" position, provided the main switch in the No. 47 board is pointing to the *H* position.

Maintenance of the No. 47 board contained in this panel is given on p. 565.

The B.A.S. bulb for interior illumination and the fuse are accessible from the front of the panel if the small nameplate is removed.

The dipswitch action should be kept well greased with vaseline. The cap can be removed by extracting the two interior fixing screws. If the switch does not operate, look for loose or broken connections or burnt-out bulbs. With electrically operated dippers a blown fuse inside the headlamp may be the cause of the trouble.

If the ammeter does not register it may be due to:

(*a*) Dynamo not charging.

(*b*) Ammeter burnt out or needle stuck.

(*c*) Faulty, dirty, or loose connections.

(*d*) Blown fuse.

Keep the plug sockets clean and free from corrosion.

The complete faceplate can be removed for instrument inspection if the four screws on the edge of the faceplate are extracted.

The bulb in the green oil-indicator lamp is automatically withdrawn with the lamp bezel if the bezel is unscrewed.

Fuse wire should be 32 S.W.G. tinned copper for dynamos types D45C, D, and D45R, and 30 S.W.G. tinned copper for types DBR, DBNB, DBLR, and DBLNB. A spare length of fuse wire is wound around the fuse bridge.

See that the fuse bridge is securely located in the fuse clips.

Switch Panel Type No. 82

This is another flush-mounting panel which is fitted with type either No. 47 or 101 switchboard, together with other instruments. Also, a blue oil-warning light is often fitted, and it should be particularly noted that it lights up when the oil flow is interrupted or the engine is stationary but still switched on. The light is controlled automatically by the ignition or pilot switches.

Maintenance for switchboards type Nos. 47 and 101 are given on pp. 565 and 568 respectively.

Switch Panel Type No. 117

This is also a steering-column mounting panel similar to type No. 65, but of different shape, and is not provided with a detachable faceplate. Type No. 47 switchboard is fitted, also an oil-warning light, starter and

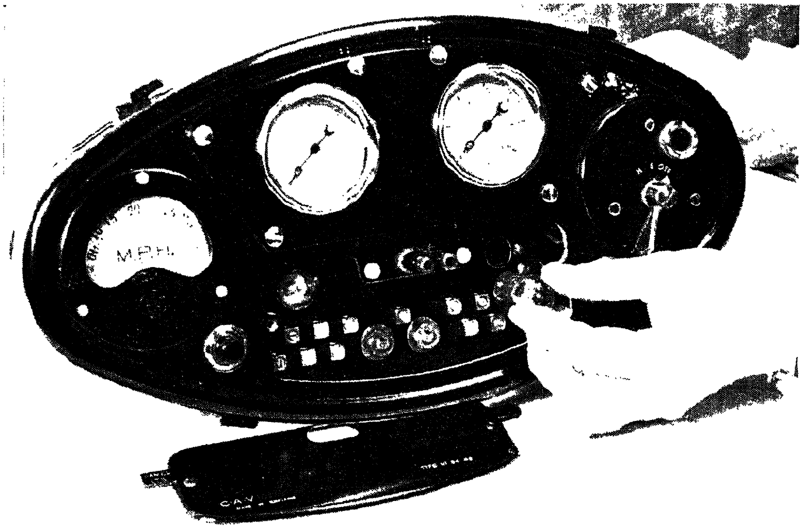


Fig. 7.—No. 54 SWITCH PANEL SHOWING BULB BEING EXTRACTED

dip switches, horn push, two-pin plug, and various instruments, all depending upon the particular type symbol of the panel.

The panel interior is easily accessible if the back cover is removed.

As distinct from type No. 65, the interior-illuminating bulb is used for the oil-warning light when required. The bulb can be extracted from front of panel if the small cover plate is removed.

All remaining maintenance details can be taken as given for type No. 65.

SWITCHES

C.A.V. switches are available for all classes of low-voltage control. Those which are built into switchboards and panels will be found dealt with separately in the first section of this article, whilst the most widely used of the remaining types are set out in the following :

Starter Switches

The BBNFA and BBNG solenoid-starter switches are simple two-step units designed for use and incorporated with axial-type starters. At the first step the switch completes the circuit to the shunt and auxiliary field windings, allowing a small current to pass, sufficient to give the starter armature its axial movement and thus gently but firmly engaging the pinion with the teeth on the flywheel. When the engagement has taken place the second circuit is completed, allowing the main current to flow

and the starter to develop its maximum power.

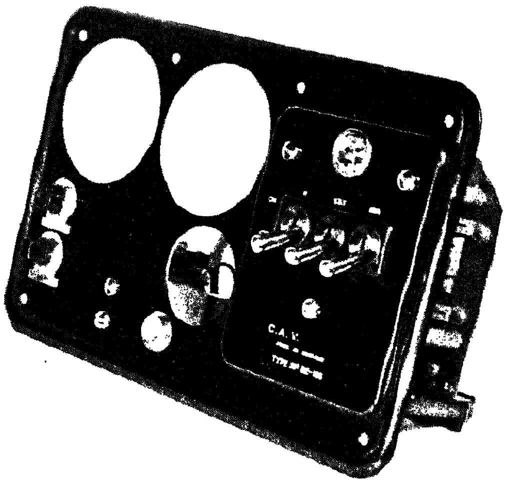


Fig. 8.—TYPE No. 82 SWITCH PANEL FITTED WITH No. 101 SWITCHBOARD AND WITHOUT INSTRUMENTS

Operation of BBNFA and BBNG Solenoid-starter Switches

Referring to Fig. 15, when the starter button is pressed the magnetic field set up in the switch windings draws in the armature (*C*) until the first contact is closed and the catch (*F*) rests on the step in the trigger (*E*). This position is held until the trigger is lifted by the trip plate on the armature during its travel, and thus allows the second contact to close and the main current to pass.

Dismantling the Switch

(*a*) Remove nut (*G*) after freeing from locking plate (*H*), take off catch-holding plate (*L*) and trigger catch (*F*), and it will then be found that bridge piece (*M*), flat spring (*K*), and insulating bush (*J*) can be withdrawn. The earlier types of BBNFA switches were fitted with a single-spring washer, and where this is found to be the case a new locking plate should be fitted.

(*b*) Care should be taken when the trigger (*E*) is released, through removing the catch (*F*), that the trigger spring (*D*) is removed, otherwise it will fall out and become lost.

(*c*) Note the position of the washers, as the thin ones are used for adjustment purposes, as explained in the assembling instructions. The thick washer acts as a spigot for the return spring (*B*).

(*d*) Remove spring (*B*).

(*e*) The fixed contacts can be removed by extracting the fixing screws (*U*). Do not omit the insulating bush or washer when replacing.

Maintenance of BBNFA and BBNG Switches

(*f*) If moving contact (*M*) is dirty, clean with spirit or very fine carborundum paper.

(*g*) If moving contact (*M*) is badly burnt or pitted, reface. Take care that both faces are kept to the original angle, and that they

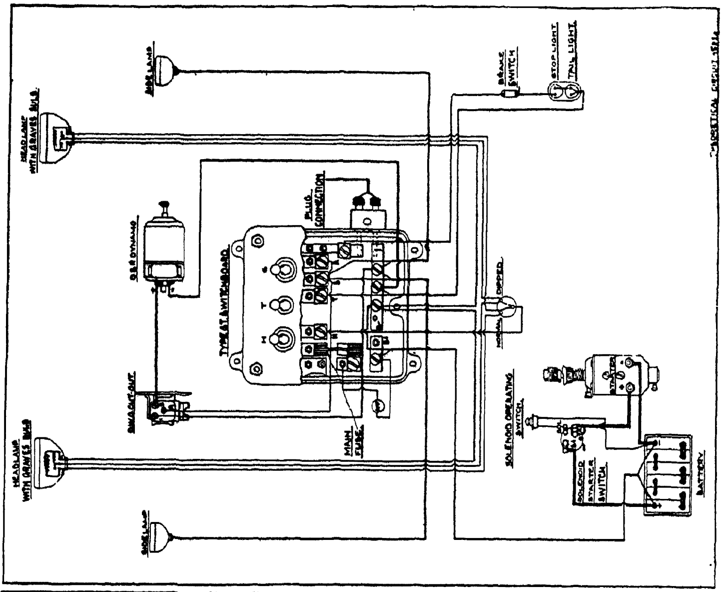


Fig. 10.—TYPICAL WIRING DIAGRAM FOR NO. 6T SWITCHBOARD

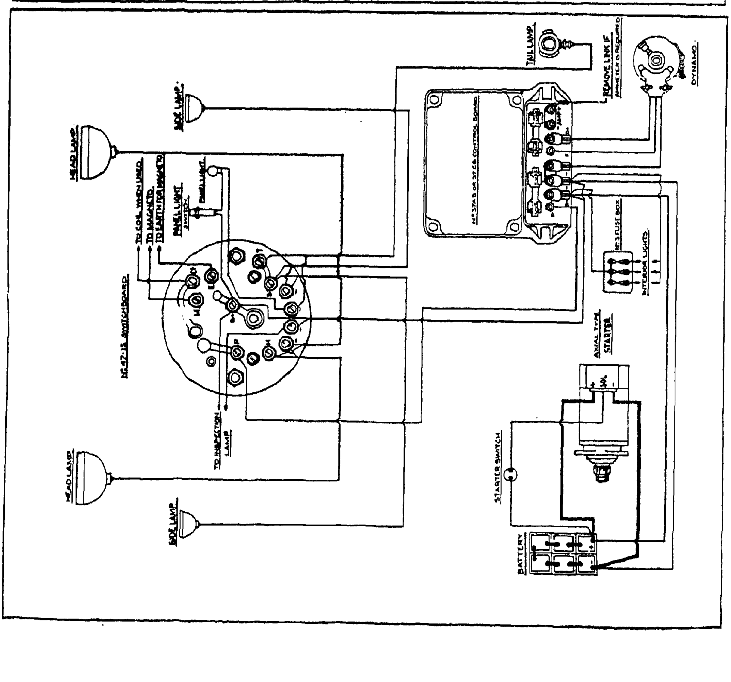


Fig. 9.—A TYPICAL WIRING DIAGRAM FOR NO. 47 SWITCHBOARD

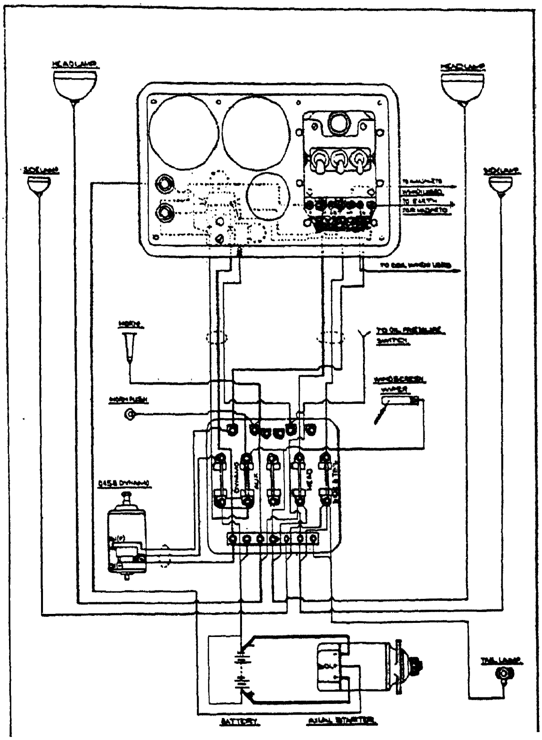


Fig. 11.—Diagram for No. 82 switch panel with No. 101 switchboard

are on the same plane. This is most important, as if the faces are uneven poor contact will result and the whole operation will have to be repeated after a short time. Not more than $\frac{1}{64}$ in. (·4 mm.) must be removed from the faces of the contacts, and in the unlikely event of this not being enough, a new bridge-piece should be fitted.

(*h*) If fixed contacts (*S*) and (*T*) are dirty, clean as for (*f*).

(*j*) Should fixed contacts (*S*) and (*T*) be badly burnt or pitted, it is recommended that they be replaced, unless facilities are available for accurate refacing by milling or turning. If refacing is undertaken, not more than $\frac{1}{64}$ in. (·4 mm.) must be removed from the surface, as in the case of moving contacts.

As new fixed contacts are supplied in an unmachined state, care must be taken to face them when in position on the switch and before placing the switch in service.

(*k*) Do not use a file or coarse grit on either the fixed or moving contacts.

(*l*) Check pressure of return spring (*B*). It should be as follows when compressed to a length of $\frac{1}{2}$ in.

BBNFA	*BBNG*
3 lb. 3 oz. $\begin{cases} + & 5 \text{ oz.} \\ - & \end{cases}$	5 lb. $\pm$ 5 oz.

If the pressure is not within these limits, a new spring should be fitted.

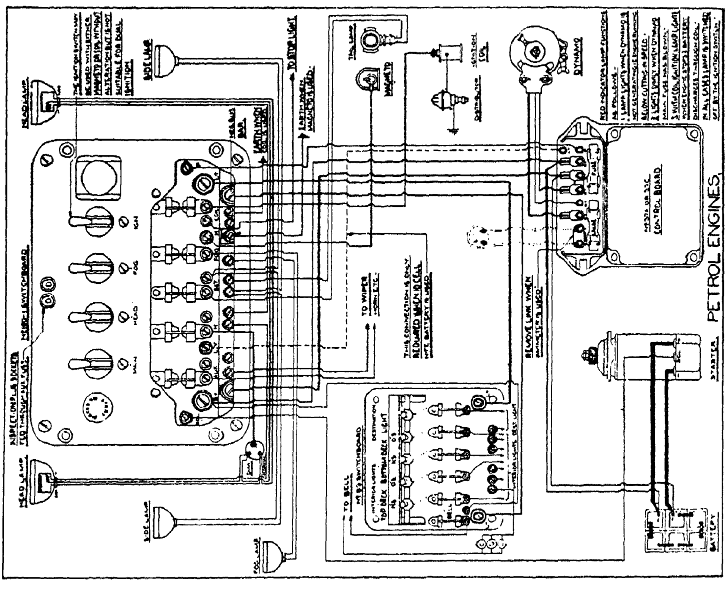


Fig. 12.—No. 100 SWITCHBOARD WIRED FOR USE WITH PETROL ENGINES

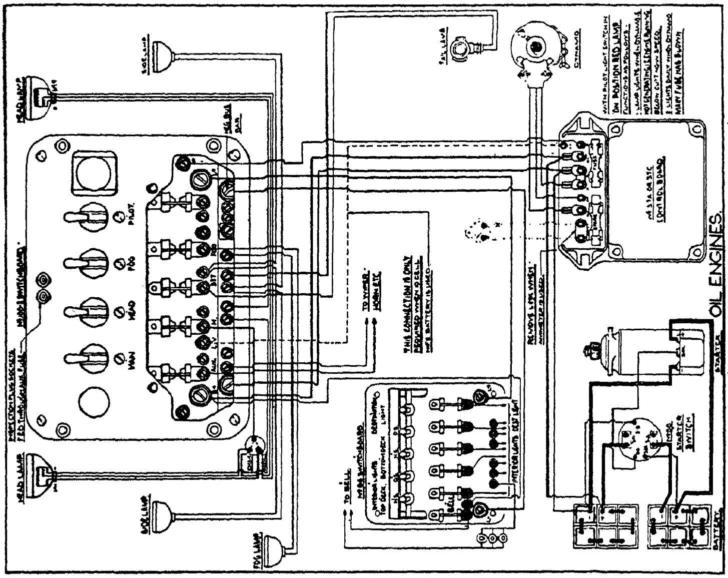


Fig. 13.—No. 100 SWITCHBOARD WIRED FOR USE WITH OIL ENGINES IN CONJUNCTION WITH A SERIES-PARALLEL SWITCH

(*m*) Check the pressure of trigger spring (*D*). It should be replaced if not within 6–10·5 oz. for the BBNFA, and 12·5 oz. to 1 lb. for BBNG switch when compressed to a length of $\frac{7}{32}$ in.

(*n*) See that insulating bush (*J*) is a nice easy fit in bridge-piece (*M*) and has not distorted through heat from exterior sources, etc.

(*o*) In the event of the winding becoming broken or damaged, the complete switch should be returned to C.A.V. for repair, as the stirrup (*A*) surrounding the coil is riveted to the main plate and should not be removed.

(*p*) Lightly smear the plunger (*C*) at the point of entry into the switch body with vaseline, also at the point of contact between the bridge-piece and the flat spring. Apply the vaseline sparingly to avoid excess getting on to the contact faces.

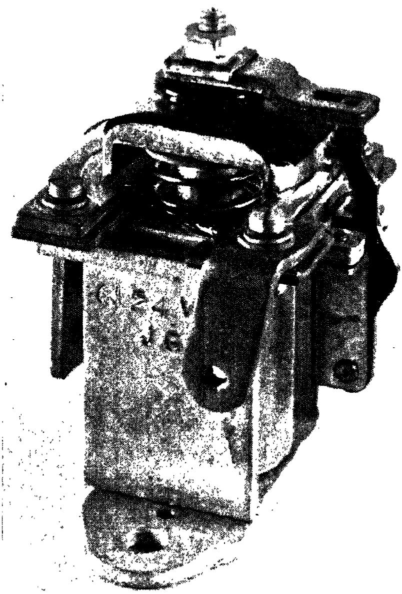


Fig. 14.—BBNG TYPE STARTER SWITCH

Assembling

Assemble and switch according to dismantling instructions reversed, but note the following points:

(*q*) *Air Gaps.*—If any refacing of the contacts has been carried out, it will be necessary to readjust the contact air gaps by removing one or more of the thin adjusting washers, but do not remove either of the other washers. The thin adjusting washers are made in the following thicknesses: ·004, ·008, and ·012 in. (0·1, 0·2, and 0·3 mm.), and the number varied until the air gaps given on figure are obtained.

(*r*) It is advisable to fit a new locking plate (*H*) for the armature nut (*G*), as the efficiency of the switch will be impaired unless the nut is kept perfectly tight.

Test Data for BBNFA and BBNG Switches

When switch is finally assembled, the following tests should be made, with the switch in a horizontal position:

(*s*) Force to overcome return spring in "OFF" position:

BBNFA	*BBNG*
- 10 oz.	5 lb. ± 5 oz.

Do not mount the switch in the immediate vicinity of any source of heat.

Beyond the following points, the actual maintenance of the S.O.L. switch is negligible :

Keep the terminals and the surface on which they are mounted perfectly free from dirt, damp, or oil.

Keep the terminal nuts well tightened. Take care not to twist the cable sockets so that they jam against the small insulation cap, otherwise there is a danger of distorting the plunger bearing, with a consequent sticking of the plunger action.

Remove occasionally the screwed cap and plunger, smear the brass stem of the plunger with vaseline, and replace.

NZ-type Starter Switch

This switch (Fig. 16) is supplied for either foot or hand operation, and is intended for breaking the main current on small starters up to and including $4\frac{1}{2}$ in. in diameter.

Two long fixing screws (G) are provided, which allow the switch to be fixed to either a metal or wooden panel.

Avoid acute bends in the cables and strains on the terminal sockets.

Keep the terminals well clear of any metallic partitions or framework.

It must be mounted in such a position that even pressure can be maintained by hand or foot whilst in operation.

Keep the terminals and the surface on which they are mounted perfectly free from dirt, damp, or oil.

The terminal nuts (H) must be tight, and care taken that the cable tags (J) do not twist and touch each other.

Apply a smear of vaseline to the main plunger (E) occasionally.

The contacts can be inspected after removing the top cover with its fixing screws (L). The contacts can be cleaned with spirit or very fine carborundum paper (do not use emery), unless they are badly burnt or pitted, when they should be renewed. Take care when reassembling the switch that the parts are replaced in their correct positions according to Fig. 16.

No. 108-type Starter Switch

The operation of this switch is on the same principle as the NZ type, but it is considerably smaller in size and is for hand operation only. It is of robust construction, and intended for operating solenoid switches or for use in any similar circuits where the load to be broken is small. It is definitely not suitable for breaking any main-starter current.

Two holes (tapped 2Ba) are provided in the cover for fixing the switch to a panel.

Keep the terminals well clear of any metallic partitions or framework.

The particulars given for the type NZ will also apply for this switch,

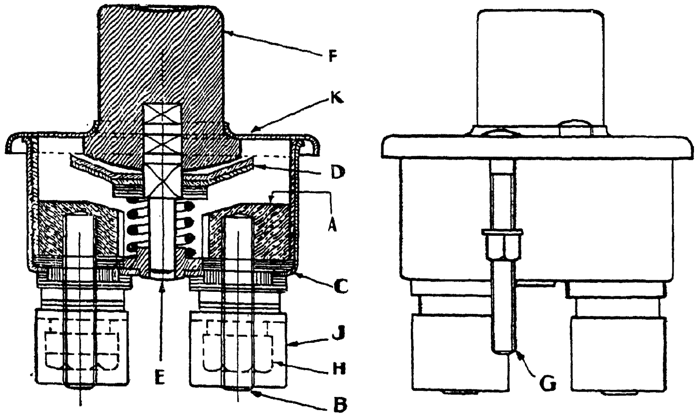


Fig. 16.—Section through NZ-type starter switch

except that the contacts are made accessible by removing the moulded insulator fixed to the body by two countersunk screws.

When the contact replacement is necessary, the moulded base, complete with contacts riveted in position, is supplied for the fixed contacts, and the moving contact is complete with the moulded knob. The knob can be extracted from the switch if the split-ring is removed.

Switch Type No. 121

This combined switch and fuse unit (*see* Fig. 17) has been specially designed with the object of simplifying the complicated wiring that is generally necessary when connecting up a bank of separate switches, and at the same time to permit switch assemblies to be built up in number by the customer according to requirements.

It is constructed of black moulded bakelite, and contains a blade-type switch, cartridge fuse, connecting terminals, and spare fuse. Slots are moulded in the base in order that the switch may be mounted, together with other switches, direct on to the bus-bars.

A nameplate for marking the name of the component controlled by the switch is attached to the base by a spring clip. It is visible through a slot in the moulded cover, but remains attached to the base when the cover is removed.

Cables are brought up through the panel to which the switch is fixed and connected to the terminals on the front of the switch base. The cables are not visible from the front of the switch when the cover is in position.

Two holes in the base are provided for fixing the complete unit.

When the switch is mounted separately, and not on bus-bars, it is

necessary for the two terminal studs at the back of the switch to be linked. A link is provided if the switch is ordered as type No. 121–2 for separate mounting.

Bus-bars are available ready drilled and cut to length, according to the number of units it is required to assemble. It should be noted that the centres of the drilled holes for the No. 121 switch and type No. 123 fuse units are different, and it is, therefore, not possible to change the position of these units on the bus-bars in relation to one another.

Main feed terminals are fitted to the bus-bar ends, and it is advisable that they should be covered, after all connections have been made, by means of the bakelite covers specially designed for the purpose.

The bus-bars are located in the slots provided in the switch base, and secured to the two rear terminals by a nut and washers.

Take care when mounting the switch to see that sufficient clearance is allowed to permit the cover-fixing screw to be released and the cover removed.

The switch is in the "ON" position when the operating dolly is pointing towards the name-plate.

Great care should be taken to remove the link from the back of any type No. 121–2 separate-mounting switch if it is ever required to be mounted on bus-bars.

The cartridge-type fuse is permanently connected in the switch circuit, a spare fuse being clipped to the base underneath the name-plate.

The main cover is removed by releasing the single milled-head screw. The screw cannot be extracted from the cover, but remains attached, to prevent it from becoming lost.

At intervals apply a smear of vaseline to the switch blades and around the ball portion of the dolly.

Keep all terminal screws well tightened and the fuse secure in its clips.

Do not alter the fuse capacity from that provided when the switch is fitted.

Battery Cut-off Switch Type No. 134

This is a hand-operated switch for breaking two main battery circuits simultaneously. The switch is mounted on a metal base and enclosed by a cover that also carries the operating knob.

The moving contact piece with plunger can be extracted from its bearing when the cover is removed. It is, therefore, important that the cover is kept firmly screwed down when the switch is in use.

Grease occasionally the plunger and clean the contacts, as explained for the type BBNFA switch. Make sure when replacing the contact piece that the keyway in the plunger is opposite the locating pin in the bearing. Lubricate the knob spindle as for BBNFA.

HEADLAMPS

Headlamps can be subdivided into various types, as follows:

Standard

Fitted with a standard single filament S.B.C. type of bulb and fixed reflector.

Electric Dip and Switch (E.D.S.)

This system makes use of a separate control switch, usually mounted on the steering column, which when moved to the "DIP" position causes the nearside reflector to be dipped and turned to the nearside of the road; at the same time the offside lamp is extinguished.

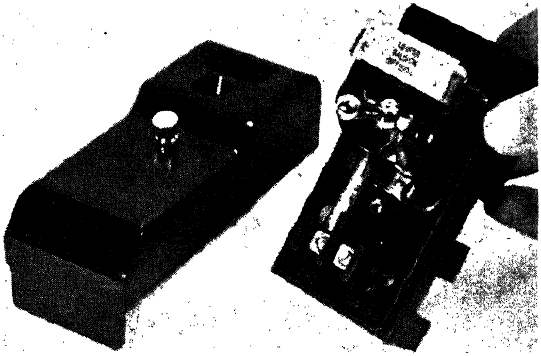


Fig. 17.—TYPE No. 121 SWITCH WITH MOULDED COVER REMOVED

The reflector of the nearside lamp in this case is pivoted on ball bearings within a fixed rim, which is in turn secured to the headlamp body. The reflector is tilted by means of a plunger controlled by an electrically operated solenoid mounted at the rear of the reflector. In order to avoid a heavy current consumption by the solenoid windings during the dipping operation, a high-resistance coil is brought into operation by the plunger at the end of its travel and holds the reflector in the dipped position

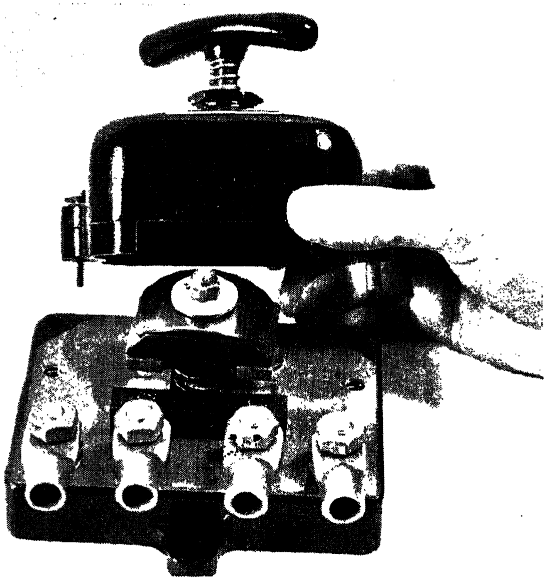


Fig. 18.—BATTERY CUT-OFF SWITCH No. 134 WITH COVER REMOVED TO SHOW CONTACTS

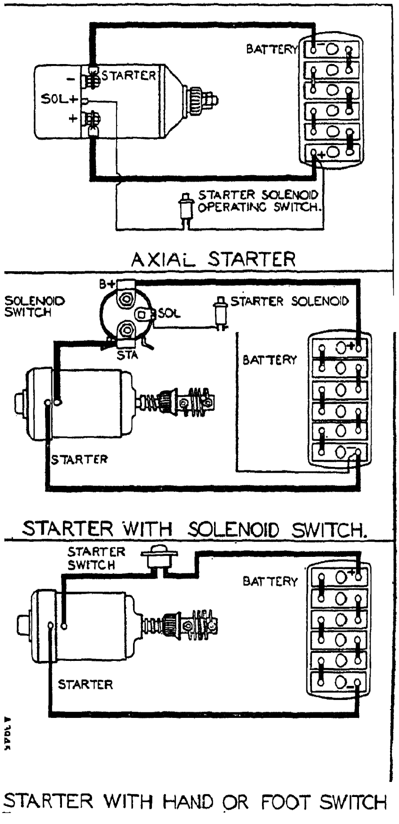


Fig. 19.—CIRCUIT CONNECTIONS FOR STARTER SWITCHES

until the current is switched off by the control switch. The reflector is returned to the normal position by spring pressure, the movement in both directions being limited by rubber buffers to prevent excessive shock to the bulb.

A fuse is provided with each electrical dipper unit in order to protect the operating coil in the event of the reflector failing to function correctly.

Twin Dipping Reflectors

This arrangement is similar to the E.D.S. system, but two dipping reflectors are used in place of one dipping and one standard reflector.

Lucas-Graves Anti-dazzle Bulbs

The dipping of the light-beam operation in these lamps takes place entirely within the bulb, the reflectors remaining stationary. The main bulb filament is the source of the normal driving beam and is, therefore, located at the correct focal region of the reflector.

A secondary filament slightly in advance of the main filament is provided on its underside with a shield that directs the rays to the top of the reflector, which, in turn, deflects and spreads them into a wide area on the road immediately in front of the vehicle. Thus the operation of the dipswitch extinguishes the main filament and lights the secondary filament, providing a flat-topped driving beam of adequate intensity and absence of dazzle. These special bulbs are fitted with caps larger than those normally used, and in addition have special pins to prevent the bulbs from being incorrectly fitted.

Duplex Reflectors

These reflectors are a special stepped design, providing a flat-topped high-intensity beam with the minimum of dazzle.

Headlamp Adjustments

When it becomes necessary to make adjustments to the lamp, the following points should be noted when dismantling, according to the respective types:

Removing the Lamp Front

Fig. 20.—Slacken the single fixing screw (a coin slot is provided in the head) and allow it to hinge out of the slot on the rim. Grip the rim firmly with both hands opposite the screw, and remove with even pressure; do not lever or jerk violently. When replacing, first locate the top of the front over the body and then apply pressure around the lower half of the rim.

Fig. 21.—Loosen the two fixing screws. When replacing, make sure that the front is evenly located around the body. Tighten screws evenly.

Fig. 22.—Slacken the single fixing screw and hinge the front upwards.

Removing the Reflector

Fig. 23.—Turn back the ends of the cork packing washer and extract the fixing screw. Twist the reflector by its outside edge until the markings "O" stamped on the reflector and body coincide, at which point the reflector may be withdrawn. Replace by engaging the reflector and body at "O" and turning to the left until the screwhole is opposite the tapped hole in the body (*see* note for right-hand road rule).

Fig. 24.—Press reflector inwards evenly and turn to the left until the locating pins come opposite the slots in the lamp body. Reverse the procedure when replacing.

Fig. 25.—On this type the reflector is automatically withdrawn when the front is removed. It can, however, be taken out of the front rim by extracting the retaining springs. Make sure that the reflector is correctly located when replacing.

Fig. 26.—The reflector will be found to be quite free when the front is removed. It is necessary only to extract the bulb to permit the removal of the reflector.

Fig. 27.—Remove single fixing screw in reflector and turn the reflector until the locating pieces come opposite the slots in the lamp body.

Right-hand Road Rule

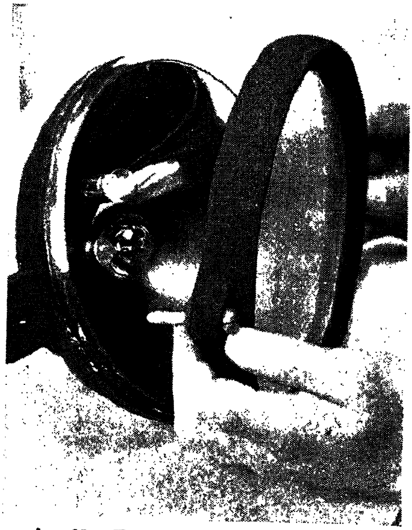
In countries where this rule exists, as against left-hand in the United Kingdom, it is necessary for the dipping reflector to operate in the opposite direction. Provision has been made for this as follows:

When replacing reflector, engage at points marked "O" and turn to the right until screwhole is opposite the tapped hole in the body.

Replace the reflector with the top support located in the slot marked "R."

Fig. 20.—REMOVING LAMP FRONT

Slacken the single fixing screw. A coin slot is provided.



ig. 21.—REMOVING ANOTHER TYPE OF LAMP FRONT

Loosen the two fixing screws.

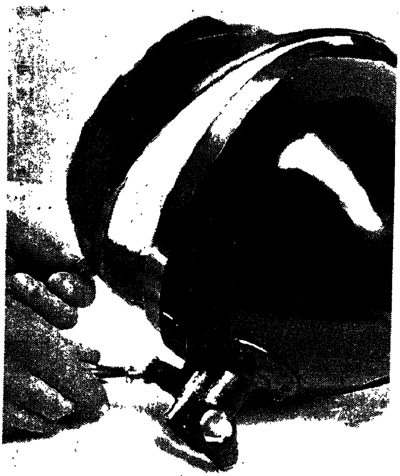


Fig. 22.—REMOVING ANOTHER TYPE OF LAMP FRONT

Hinge the front upwards after slackening set-screw.

Fig. 23.—REMOVING REFLECTOR

Turn back ends of the cork packing and extract fixing screw.

Focusing

All C.A.V. headlamps are accurately focused and adjusted before leaving the works, in order to give the maximum efficiency. Often, however, this adjustment is upset when a bulb replacement is made, and refocusing becomes necessary.

Three Methods of Focusing

Alternative forms of focusing are used as follows:

(*a*) Fig. 28.—Slacken the clamp screw or spring holding the lamp holder, and move the lamp holder to and fro until the desired effect is obtained. Do not forget to retighten clamp screw.

(*b*) Fig. 29.—On other lamp holders alternative positions are provided for the bulb by three different slots in the holder itself.

(*c*) Fig. 30.—A simple method of focusing, effected by turning a milled nut at rear of lamp holder.

Lamps fitted with Lucas-Graves bulbs do not need any form of adjustable focus, owing to the accurate alignment of the reflector and bulb filament.

Alignment of Headlamps

Park the vehicle opposite to and at least 25 ft. away from a wall, making sure that the vehicle is positioned at right angles to the wall, so that the headlamps are equidistant from it. The lamps should then be aligned so that the horizontal axis of the oval light area on the wall is below 3 ft. 6 in., measured from ground-level, and the lamp centres are equidistant from the vertical axis.

Bulb Replacement

The importance of replacing bulbs with those of the same size and of good quality is not, as a rule, fully appreciated. Inferior-quality bulbs often have the filaments of such a shape as to make accurate focusing impossible, a similar effect being also set up by the sagging filaments in good-quality bulbs after long service. It is therefore earnestly recommended, for headlamps and pass lights at least, that Lucas "Blue Star" high-efficiency bulbs be fitted, all of which have been carefully manufactured and tested for accurate focusing. Conforming to the Ministry of Transport regulations, all bulbs supplied by C.A.V. have the wattage, in addition to the B.A.S. number, clearly stamped on the cap.

Fuses

The small cartridge fuse used in conjunction with the dipping reflector is fitted in spring clips mounted alongside the dipping mechanism. If the fuse has blown, replace by the spare fuse mounted on the support bracket, after having ascertained and rectified the cause of the failure. A sticking reflector, due to the lack of lubrication, will cause the fuse to blow.

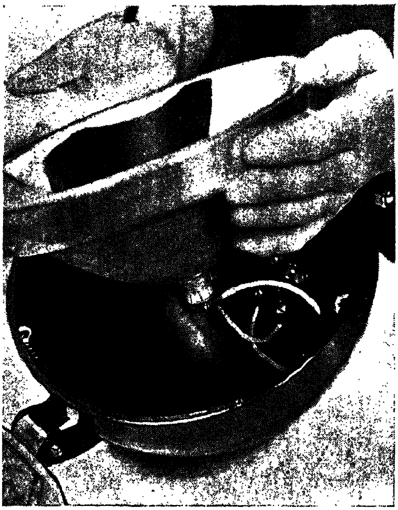
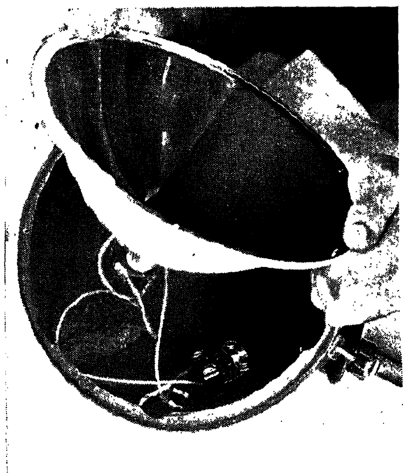


Fig. 24.—TO REMOVE REFLECTOR

In the type shown, press reflector inwards and turn.

'ig. 25.—ON THIS TYPE OF LAMP THE REFLECTOR IS AUTOMATICALLY WITHDRAWN WHEN THE FRONT IS REMOVED

Fig. 26.—IN THIS TYPE THE REFLECTOR WILL BE FREE WHEN THE FRONT IS REMOVED



'ig. 27.—TO REMOVE THIS TYPE REFLECTOR UNSCREW FIXING SCREW AND REFLECTOR

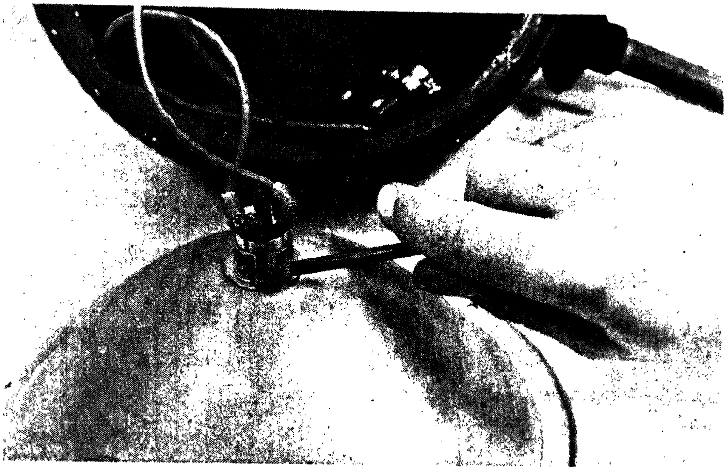


Fig. 28.—ONE METHOD OF ADJUSTING FOCUS

Slacken clamp screw or spring holding lamp holder, and move lamp holder to and fro until desired effect is obtained.

OTHER LAMPS

Pass Lights

In the main, the instructions for the headlamps will equally apply for pass lights.

With some pass lights it will be found that focusing is carried out in a simple manner by turning in the direction required the large round knurled nut located behind the lamp holder.

Pass lights should be mounted below the normal headlamp level,

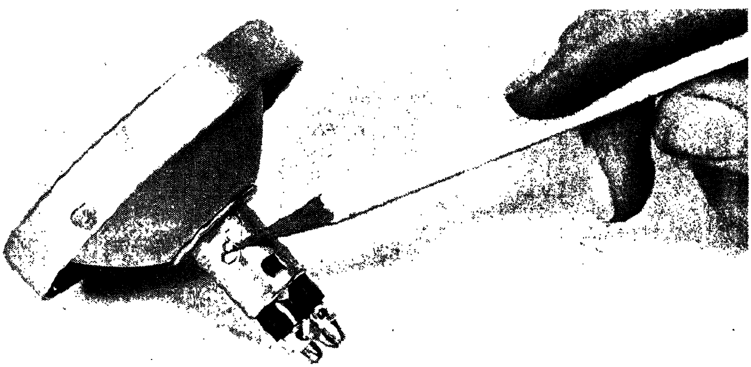


Fig. 29.—ANOTHER METHOD OF ADJUSTING FOCUS

In this lamp holder three slots are provided for the bulb, giving three alternative positions.

Fig. 30.—A SIMPLE METHOD OF FOCUSING
Turning a milled nut at rear of lamp holder.

preferably on the nearside of the vehicles, and permanently turned towards that direction.

Side Lamps

The lamp holder with three alternative bulb locations is the method usually employed for focusing.

With the exception of lamps with two screws fixing the front, reflectors and fronts can be removed by pressing evenly inwards and turning to the left until the locating pieces come opposite the slots.

Tail Lamps

No focusing is necessary.

The bulb may be changed by either unscrewing or pulling off the cap containing the red glass.

" Stop " Tail Lamps

The front may be removed by releasing the single fixing screw and gently lifting the lower half of the rim.

General Maintenance

Reflectors should be handled and cleaned with great care. Metal polish should on no account be used. A light polish with a soft cloth or clean chamois leather is all that is necessary. If any other method is used, the transparent colourless covering protecting the highly polished surface will be damaged and rendered useless.

On dipping reflectors the movement should be perfectly free and uninterrupted. The pivot and bearings should be periodically lubricated with thin machine oil.

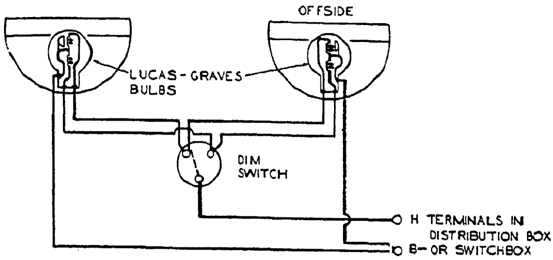
See that the cables do not foul the reflector. If there is any stiffness in the movement, apply the slightest smear of machine oil to the moving plunger of the dipping unit and the bearings on which the reflector is pivoted.

Ordinary enamelled-finish lamps can be cleaned with a good car polish. Chromium-plated parts need only to be occasionally wiped over with a damp cloth to remove dust or dirt.

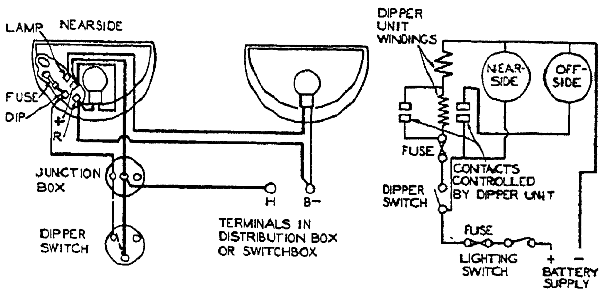
Make sure that all connections are perfectly tight.

WINDSCREEN WIPERS

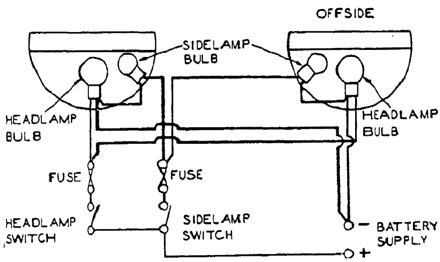
The C.A.V. windscreen wiper, type BWN (Fig. 32), is designed for either 6-, 12-, 24-, or 30-volt circuits, and consists of a small electric



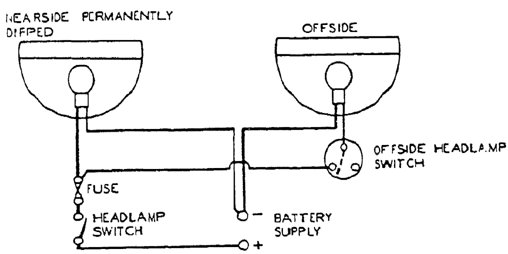
(*Left*) Diagram for headlamp with Lucas-Graves bulbs.



(*Right*) Diagram for headlamp with dip and switch reflectors.



(*Left*) Diagram for combined head and side lamp.



(*Right*) Diagram for headlamps with nearside permanently dipped and with separate switch for offside.

Fig. 31.—Circuits for various types of C.A.V. headlamps

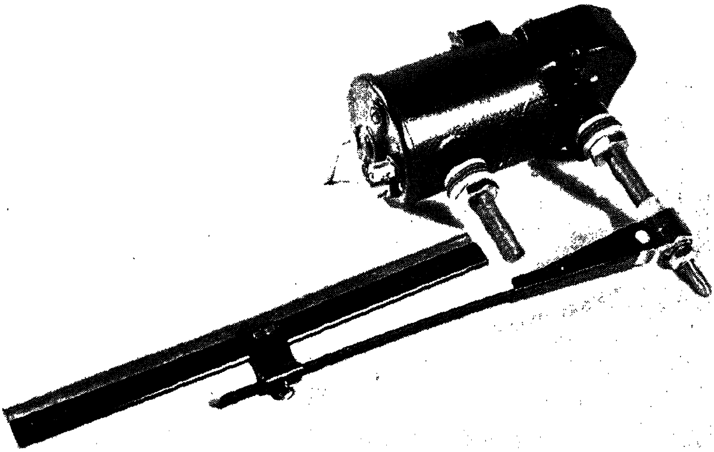


Fig. 32.—WINDSCREEN WIPER, TYPE BWN

geared motor driving the arm which holds the squeegee. The oscillatory movement of the wiper arm is produced by means of a crank connected to the reduction gears.

A control switch is incorporated in the end cover on the standard model, but the wiper can be supplied without this switch if it is desired to fit a control separate from the wiper.

Construction and Operation

Referring to Fig. 33, the worm (*A*) is cut on the end of the armature shaft and drives the worm-wheel (*B*) with a high-reduction ratio. The latter carries the crankpin (*C*) which, by means of the connecting rod (*D*), gives the toothed segment (*E*) an oscillating motion. The toothed segment (*E*) engages on one side with the pinion (*F*) fixed to the wiper spindle, so that the latter oscillates with the toothed segment.

Fitting

It is essential that the fixing-hole centres (58-mm. standard wiper) are accurately spaced and bored parallel to each other ; they should also be at right angles to the face against which the wiper is clamped. Make sure that the clamping face is perfectly flat and smooth; remember to use the rubber washers and tighten the fixing nuts evenly.

Neglect of any of these points is liable to cause distortion of the spindle bearing, with the consequent seizure of the blade spindle.

Adjustment

The armature can be removed from the housing if the screws (*G*) are released and the end cap (*H*) taken off. The brush gear should be

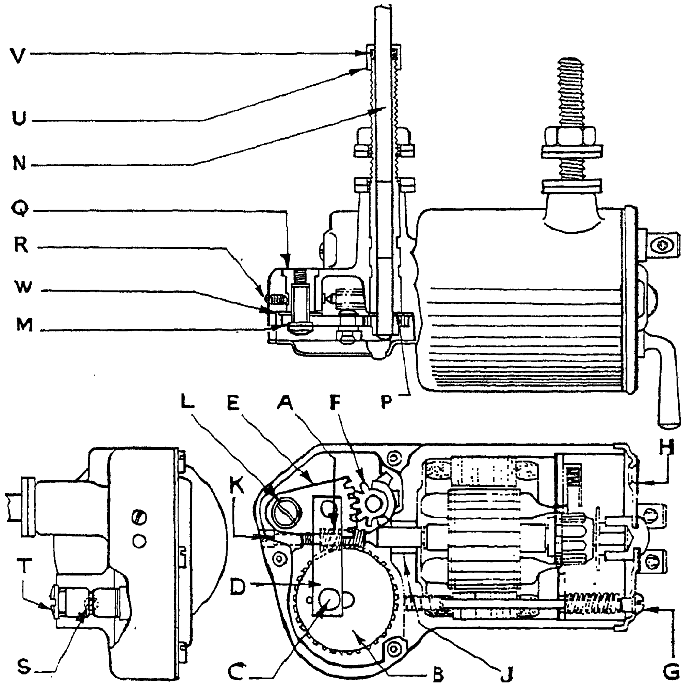


Fig. 33.—C.A.V. TYPE BWN WINDSCREEN WIPER PARTIALLY SECTIONED TO SHOW INTERIOR CONSTRUCTION

extracted from the body the maximum amount possible without releasing the connections to the brush boxes.

Do not cut off the threaded spindle bearing, as the recessed portion of the spindle will be exposed with consequent loss of bearing surface and grease. A packing piece is available to compensate for thin windscreens.

The centre of the worm-wheel (*B*), driving-end bearing (*J*), and armature setscrew (*K*) must be dead in line when viewed through the wiper body after the armature has been removed. As the armature setscrew and driving-end bearing are permanently and accurately centred with each other, it is necessary only to adjust the relative position of the worm-wheel.

To make this adjustment, remove the complete worm-wheel and segment assembly after extracting the screw (*L*), and insert thin packing shims (obtainable at any C.A.V. Service depot) between the worm-wheel

ulder.

be taken that the coupling bar between the worm-wheel

and segment is not distorted when any adjustment is made to the worm-wheel. The bar must be parallel with the machined cover-plate face of the housing, and it can be accurately aligned by the means of packing shims (*W*) behind the segment. When the segment-fixing screw is screwed home as far as it will go, the segment should work freely but must not be loose; any looseness can be rectified by the means of packing shims behind the fixing-screw head (*M*).

With the armature still out of the wiper, see that the worm-wheel assembly when in position is perfectly free and easy in movement.

Insert the spindle blade (*N*), complete with its locating spring (*P*), so that the centre tooth of the spindle gear meshes with the centre of the segment, and turn the spindle to make sure that there is no restriction in movement. Ease off the segment bearing setscrew (*Q*) and rotate the bearing by means of the screwdriver slot until the segment teeth and those of the spindle tighten up. Continue to rotate the bearing slowly until the whole assembly is perfectly free in movement; screw in the setscrew (*R*).

Insert the armature and replace the brush gear, making sure that the brushes are correctly bedded on the commutator. Replace the end cap (*H*), with the switch handle pointing towards the "OFF" position, and screw in securely the fixing bolts.

The wiper should now be motored and the armature setscrew (*K*) tightened until the armature is locked; then turn back the screw half a turn, switch off the wiper, and seal the setscrew. When this has been completed, motor the wiper again and ease off the worm-wheel bearing setscrew (*S*), and turn the bearing (*T*) by means of the screwdriver slot until the machine locks solid. Turn back the worm-wheel bearing screw until the wiper motors freely with a current consumption of not more than 1 amp.; tighten the setscrew (*S*). Half-fill the gearbox with a good-quality soft grease, replace the cover plate, and tighten securely all screws.

Maintenance

If the running of the wiper becomes erratic, and it is known that all the gearing is perfectly free, inspect the brushes and commutator.

If the commutator surface is dirty or discoloured it should be cleaned with very fine glass- or carborundum paper (do not use emery cloth). After cleaning the commutator surface, the slots between the segments should be cleared of all deposit.

The brushes should not be worn below a length of $\frac{5}{32}$ in. (3·9 mm.), and should be properly bedded, i.e. they should be worn to the commutator periphery. If they are not, wrap a strip of very fine glass- or carborundum paper firmly around the commutator, and with the brushes in position rotate the armature by hand in the normal working direction of rotation until the correct brush shape is obtained.

See that the gland nut (*U*) and washer (*V*) are retained in position.

ERRATA

Vol. I, page 60, Fig. 8. Should read " Drawing gudgeon pin in with special tool."

Vol. I, page 235, Fig. 4. Shown upside down.

Vol. II, page 6, 4 lines from bottom. For " six main bearings " read " seven main bearings."

Vol. II, page 75, last line. For " 50° " read " 5°."

Vol. IV, page 338, line 22. For " with " read " will."

Vol. IV, page 338, next to last line. For " dose " read " close."

Vol. IV, page 342, lines 17 and 19, and page 345, line 32. For " yield " read " field."

Vol. IV, page 344, six lines from bottom, and page 347, line 14. For " shortening " read " shorting."

Vol. IV, page 346, line 11. For CH5E read C45E.

Vol. IV, page 346, lines 26 and 27. For " mains' " read " main."

CLASSIFIED KEY

BODYWORK

CLUTCH BRAKES

CLUTCH OVERHAUL

CLUTCH TROUBLES

ELECTRICAL EQUIPMENT

BATTERIES

CUT-OUTS

DYNAMO CONTROL

DYNAMOS

ELECTRICAL ACCESSORIES

ENGINES

COMPRESSION-IGNITION ENGINES

CONNECTING RODS

CRANKSHAFTS

CYLINDERS

CYLINDER HEADS

DECARBONISING

DISTRIBUTOR DRIVE GEAR

ENGINE DISMANTLING AND REASSEMBLY

ENGINE MOUNTINGS

ENGINE TESTING AND TUNE-UP

ENGINE UNIT REMOVAL

FLYWHEELS

IGNITION TIMING

MAIN BEARINGS

MANIFOLDS

PISTON RINGS

PISTONS

TIMING CHAIN AND GEARS

TIMING COVER

VALVE CLEARANCES AND TAPPET ADJUSTMENT

VALVE GUIDES

VALVE SEATS

VALVE TIMING

VALVES AND VALVE GEAR

FRAME

FRONT AXLE

FUEL SUPPLY

OIL-FUEL INJECTION EQUIPMENT

PETROL FUEL-FEED PUMPS

GEARBOXES

DISMANTLING AND REASSEMBLING

OIL FILTERS

OIL GAUGES AND INDICATORS

OIL PUMPS

PROPELLER SHAFT AND UNIVERSAL JOINTS

REAR AXLE

BEVEL-GEAR DRIVE

DOUBLE-REDUCTION GEAR

HUBS

REAR-AXLE CASINGS

LEAF SPRINGS

SHOCK ABSORBERS

SPRING SHACKLES

WATER COOLING SYSTEM

FANS

RADIATORS

THERMOSTATS AND THERMOMETERS

WATER PUMPS

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